UNIVERSITY OF NAIROBI

IMPACTS OF CLIMATE VARIABILITY ON LIVELIHOODS SUSTAINABILITY IN KAPSOKWONY DIVISION, MT. ELGON DISTRICT, KENYA

BY

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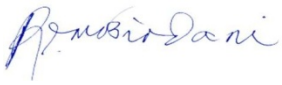
PLAGIARISM STATEMENT

I hereby declare that this thesis entitled "Impacts of Climate Variabilities on Livelihoods Sustainability in Kapsokwony Division, Mt. Elgon District, Kenya" **is** my own original work written in my own words in accordance to the University of Nairobi Regulations on Conduct of Examinations and it has never been presented for a degree in another University.

Signature…  ……Date…22 /11 / 2023

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DEDICATION

This thesis honours my late daughter Ann Kathlene Nasambu Sindani, who died in a car accident in December 2005 while studying Zoology and Botany at Kenyatta University.

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ABSTRACT

Mountains offer a special setting for identifying climate change and evaluating its effects. Long and short term climate variabilities continue to impact livelihoodsof small-holder farmersin the study area. People who live adjacent to Mount Elgon Forest Ecosystem are particularly susceptible to harsh climatic occurrences, as well as widespread poverty and marginalization. The present-day research was carried out in Kapsokwony Division, Mt. Elgon District, Kenya. The traditional adaptive technological techniques are insufficient to inadequately address the impacts of climate change on livelihoods. The main objective was the analysis of thirty (30) years historical climate data from 1986 - 2015 for trends, variability and villagers' perceptions. The specific objectives were to evaluate the extent to which climate change and variability had impacted livelihoods in the research region; and to investigate coping and adaptation techniques utilized by households in response to various climate change and variability and make policy recommendations to manage future climate change impacts on livelihoods. The study was a collective collaboration approach among actors to generate transformation knowledge to increase adaptive capacity and enhance resilience. The study's climate secondary data of rainfall and temperature were acquired from Kitale Meteorological Station. Whereas another source of secondary data was from desktop analyses of public and unpublished materials (KMS), government statistics, non – government organizations and the internet. The primary data were collected by use of household survey questionnaires (HHs), Fouse Group Discussions (FGDs), Key Informant and Key In-depth interviews (KIIs). The household survey questionnaires on livelihoods were administered to heads of households to complement the required information. Both primary and secondary data were collected, coded and analysed using statistical and thematic techniques. Data coding entailed cleaning, manipulating and organization of the information into categories for easy computation and analysis. The findings were then displayed in graphs, charts, tables and presented in thematic or descriptive formants. Homogeneity test of climate weather checked for the completeness and consistency of rainfall and temperature data derived single mass curve plots with single, straight lines. The Standardized Anomaly Index (SAI) was used to analyse data for the wet and dry years. From the Student'st- test analysis, the trend of the annual rainfall has been increasing generally as indicated by a slope of 9.96 but with a small Coefficient of Determination (R^2) of 0.28. Linear regression analysis depicted that March, April, and May (MAM) trends have been declining, while the October, November and December (OND) trends have been increasing. The F-test was used to analyse climatic variability showed that rainfall patterns in the study area had become unpredictable and irregular. Results of annual surface temperature analysis indicate that has been increasing over the study period. Over 90% of the farmers polled said they had noticed changes in climate patterns as far back as 30 years. Overall, the findings suggest that climate change and variability are continuing. Climate impacts on livelihood vulnerabilities, land use, livestock, and economic trees, food security, income- generating activities, weather-related events, and the onset of climatic changes were examined, and it was discovered that climate has had a significant impact on livelihoods and socio-economic development. Newtransformation of knowledge, community empowerment, adaptive capacity, enhanced resilience, collaborative learning, livelihood diversification, participatory attitude, and behavioural change were all achieved as a result of the research project.. New adaptive techniques and increased resilience will aid in the reduction of poverty, improvement of people's livelihood well-being, and socio-economic growth were achieved. The research aimed at creating awareness, scaling up livelihood actions on climate change, reducing vulnerability and enhancing resilience to improve livelihoods and sustain socio-economic development. The new societal knowledge was used to elucidate long term robust policy recommendation, adaptive strategies and enhance climate resilience, help eliminate poverty levels, improve livelihoods and sustain social economic development.

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ACRONYMS AND ABBREVIATIONS

ALP	Adaptive Learning Programme
ART	Annual Rainfall Trends
ATT	Annual Temperature Trends
BK	Biko Kapkorret
CA	Correlation Analysis
CCIV	Climate Change Impact and Vulnerability
CSA	Climate Smart Agriculture
DACO	District Agricultural Crop Officer
DALO	District Agricultural Livestock Officer
DEO	District Education Officer
DS	Descriptive Statistics
EA	East Africa
EH	Eastern Himalayas
FAO	Food Agricultural Organization
FGD 1	Focus Group Discussions 1
FGD 2	Focus Group Discussions 2
FGD 3	Focus Group Discussions 3
GCF	Green Climate Fund
GMOs	Genetically Modified Organisms
GoK	Government of Kenya
HLP	Head of Livestock Production
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
ICCA	Institute for Climate Change and Adaptation

ATAR	Adaptation Technical Analysis Report and
JJA	June July August
KALRO	Kenya Agricultural Livestock Research Organization
KARI	Kenya Agricultural Research Institute
KEPHIS	Kenya Plant Health Inspection Unit
KII's	Key Informant and In-depth Interviews
KMDC	Kapsokwony Multi-Purpose Development Centre
KMS	Kitale Meteorological Station
KRC	Kenya Resource Centre
MA	Ministry of Agriculture
MAM	March April May
MCA	Member of County Assembly
ME	Microsoft Excel
MEE	Mt. Elgon Ecosystem
MEECN	Mt. Elgon Environment Conservation Network
MO	Medical Officer
MTAR	Mitigation Technical Analysis Report
NACCP	National Adaptation Climate Change Plan
NAPAs	National Adaptation Plans of Actions
NGOs	Non-Governmental Organizations
OND	October November December
PC	Population Census
PELIS	Scheme for the Establishment of Plantations and theImprovement of Livelihoods
R^2	Coefficient of Determination
ROK	Republic of Kenya
S^2	Variance
SAI	Standardized Anomaly Index
SD	Standard Deviation
SE	Standard Error

SEE	Residual Sum of Squares
SEKU	South Eastern Kenya University
SPSS	Special Program for Social Sciences
SSTs	Sea Surface Temperatures
UN	United Nations
UNFCCC	United Nation Framework Climate Change Conference
UoN	University of Nairobi
WB	World Bank
WRI	Water Resources International
WWAP	World Water Authority Programme

GLOSSARY OF TERMS

Actors: "These are persons and institutions in public agencies, the private sector and civil society who are involved in one way or another in the problem field. Their relation to the problem field is the reason why trans-disciplinary researchers work with them. Participatory research goes beyond doing research with actors implying that actors can help shape the research process to achieve end results" (Adger 2006).

Adaptation: "It is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities or the ability to live with the changes in our environment. Changes made to better respond to climatic or environmental conditions thereby reducing harm or taking advantage of opportunity. Adaptation can help us improve our ability to cope with or avoid harmful impacts by accessing capital goods, measures focused on information, capacity building, policy and strategy development, and institutional arrangements" IPCC (Intergovernmental Panel on Climate Change), 2007.

Adaptive abilities: "It is the potential or ability of a system, region, or community or even an individual to adapt to the effects or impacts of climate change. Enhancement of adaptive capacity represents a practical means of coping with changes and uncertainties in climate, including variability and extremes. In this way, enhancement of adaptive capacity reduces vulnerabilities and promotes and in a broad interpretation of adaptation to include adjustment in natural or human systems in response to experienced or future climatic conditions or their effects or impacts" according to IPCC, 2007.

An assessment: "It is a judgment or decision based on an examination of available information about the amount, value, quality or importance of something. A 'scientific assessment' is an evaluation of a body of scientific or technical knowledge that typically synthesizes multiple factual inputs, data, models, assumptions and/or applies best professional judgment to bridge uncertainties in the available information" (IPCC, 2001).

Capacity building: "In the context of climate change, it is the process of developing the technical skills and institutional capability in developing countries and economies in transition to enable them to address effectively the causes and results of climate change" (IPCC, 2014).

Case study: "This is an assessment that requires the integration of various research paradigms. Comprehensive comparisons of results obtained or derived from various disciplines go beyond the scope of any particular project and rather represents a long term enterprise. It begins by making an assumption upon which our study has to be based, and at the same time develop schemes to overcome pertinent uncertainties or shift the burden to reduce these uncertainties from the research community to powerful market-based institutions. The way forward is to invest in several disciplines and have the results defined by the community" (IPCC, 2012).

Climate change: "It means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" (Hannah *et al.,* 2005).

Climate variability: "It refers to natural variations in the mean state and other statistics (such as standard deviation, occurrence of extremes, and others) of climate at all spatial and temporal scales beyond that of individual weather events. It is also said to be the dispersion, the clustering, the scattering or the divergence of vales within or around the centre of distribution" (IPCC, 2014).

Deforestation: "It is the conversion of forest to non-forest. It is complete removal of forest canopy for intended purpose e.g., conversion to agriculture or to pastureland or human settlement" (IPCC, 2012).

Hazards: "It is a physical event (natural hazard) that can pose a threat to a system if the system is vulnerable to the hazard. Hazards discussed in the climate change context include floods, cyclones, hurricanes, typhoons, droughts, hail or snow storms, etc. Hazard is often used in a way that implies risk, but in reality, if a flood occurs in an area that is not vulnerable to floods, there is no risk involved. Of course, risk without hazard is not possible, and therefore hazard is conceptually linked with damage and loss" (Lovejoy, 2005).

Intergovernmental Panel on Climate Change (IPCC): "Established in 1988 by the World Meteorological Organization and the UN Environment Program, the IPCC surveys world-wide scientific and technical literature and publishes assessment reports that are widely recognized as the most credible existing sources of information on climate change. The IPCC also works on methodologies and responds to specific requests from the Convention's subsidiary bodies. The IPCC is independent of the Convention" (IPCC, 2007).

Livelihoods: "The term livelihoods are understood as the ensemble or opportunity set of capabilities, assets, and activities that are required to make a living. They depend on access to natural, human, physical, financial, social, and cultural capital (assets); the social relations people draw upon to combine, transform, and expand their assets; and the ways people deploy and enhance their capabilities to act and make lives meaningful. Livelihoods are dynamic and people adapt and change their livelihoods with internal and external stressors. Ultimately, successful livelihoods transform assets into income, dignity, and agency, to improve living conditions, a prerequisite for poverty alleviation. Climate change affects livelihoods of households' dependent on available opportunities" (WRI *et al.,* 2008).

Mitigation: "It is the intervention by humans to reduce the sources or enhance the sinks for the removal of greenhouse gases from the atmosphere. Examples include using fossil fuels more efficiently for industrial processes or electricity generation, switching to solar energy or wind power, improving the insulation of buildings, and expanding forests and other "sinks" to remove greater amounts of carbon dioxide from the atmosphere" (IPCC, 2007).

Non-Governmental Organizations (NGOs): "These are organizations that are not part of a governmental structure that include environmental groups, research institutions, business groups, and associations of urban and local governments" (UNEP, 2006).

Resilience: "It is the ability of human or ecological systems to absorb disturbances while retaining the same basic structure and ways of functioning, as well as the capacity of those systems to cope with, adapt to and recover fully or partially from stress and change" (IPCC, 2014).

Sustainable development: "This is a global socio-political model for changing practices and institutions in order to achieve more equitable opportunities within and between generations while taking into account limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs. Promoting sustainable development therefore necessitates deliberations and decision making" (IPCC, 2007).

The poor: "Persons experiencing various deprivations, people living in poverty, and people who are socially and economically disadvantaged are referred to as 'the poor. This is part of a larger paradigm than income-based measurements that recognizes poverty and prosperity gradients. This livelihood lens also exposes how climate change affects people in diverse ways"

(IPCC, 2014).

Vulnerability: "This is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity. In this study, vulnerability is taken to mean the degree to which a unit is susceptible to harm due to exposure to a perturbation or stress, and the ability of the exposure unit to cope, recover or fundamentally adapt" (Thornton *et al.,* 2014).

CHAPTER ONE: INTRODUCTION

1.1 Background

Climate change and volatility can have major ramifications for people's livelihoods and natural ecosystems. Climate change is undeniable, and it has increased to unprecedented levels in recent decades and millennia (IPCC, 2014). Any increase in global average temperature of more than 2°C is expected to result in severe changes in ecosystem structure, function, and geographic ranges, putting biodiversity's livelihoods and survival at risk (IPCC, 2014). Climate change has an impact on emerging countries' socioeconomic condition, particularly those that rely on natural resource-based livelihoods. Climate and non-climatic stressors may have a significant impact on the ecosystem's enjoyment. The enjoyment of the ecosystem may be significantly impacted by climatic and non-climatic pressures. Kenya's climate is already changing (NCCAP, 2018). The long rains, May-April-May (MAM), have been shorter and dryer, and the short rains, October-November-December (OND), have gotten longer and wetter, despite the fact that overall annual rainfall has remained low (NCCAP, 2018).

Mountains have a significant impact on global precipitation and temperature patterns. The increase and fall of rainfall across mountains on the windward and leeward sides creates humid and arid climate regimes, respectively. As a result, people's lifestyles on both sides of the border are very different. The richness of livelihoods on the windward slopes of mountains is owing to the high rainfall, which allows for more agricultural output than on the leeward sides. Such inconsistencies have been reported in Kenya's Mount Elgon region (Olago *et al.,* 2004). Some of the mountains in the world that experience this phenomenon include the Rwenzori Mountains in Uganda (Taylor *et al.,* 2009), the Himalayas (Negi *et al.,* 2009), the Aberdares highlands in Kenya (Kipkoech *et al.,* 2019), Mount Kilimanjaro in Tanzania (Kilungu *et al.,* 2019), the Rocky Mountains in the United States (Wallace *et al.,* 2021; Cuni-Sanchez *et al.,* 2019).

Despite some skeptics (IPCC, 2018; Washington and Cook, 2011), scientists agree that climate change is occurring and is being caused by mankind's unsustainable habits, including the combustion of fossil fuels, industrial pollution, deforestation, and land use changes (IPCC, 2018; Canadel *et al.,* 2010; Weart, 2010; Cook *et al.,* 2013). Climate-related risks for natural and human systems were found to be higher under hotter surface temperature thresholds, according to the chosen projection. The degree of these risks depends on many factors, such as the rate,

duration and magnitude of warming, geographic location; levels of development and vulnerability, and on and human responses through adaptation and vulnerability; and on human respond on adaptation and mitigation. (IPCC, 2018). Due to the changing weather patterns, dwindling pastureland, and exponential population growth, crop production has decreased and animal productivity has declined in recent years (NCCAP, 2018). There is need to increase adaptive capacity and enhance resilience to raise agricultural output to better livelihoods socio-economic development.

Human activities have been responsible for a worldwide average temperature increase of between (0.8°C and 1.2°C) (1.4°F and 2.2°F) since pre-industrial times, according to available scientific evidence published by the IPCC in 2018, with most of the warming observed over the world occurring in the Arctic (IPCC, 2018). Limiting global warming to 1.5°C, rather than to 2°C or more can reduce the impacts of climate change on livelihoods. Limiting global warming may also provide greater opportunity for people and ecosystems to adapt and stay below relevant rick thresholds. To keep global warming to 1.5°C, rapid changes in land, energy, industry, buildings, transportation, and cities are required (IPCC, 2018). This will most certainly have a detrimental influence on the water resource sector, resulting in food insecurity and, as a result, a loss of livelihood according to studies in the Lake Basin by Olaka *et al.,* 2019 on anticipated Climatic and Hydrologic Changes to Lake Victoria Basin Rivers under Three RCP Emission Scenarios for 2015-2100.

The severity and frequency of climate change impacts have increased perceptions of climate change as a concern around the world over the years (UNDP, 2007), but it is still not regarded a priority environmental issue, particularly in affluent countries (Leiserowitz et al., 2005; Leiserowitz, 2006; Pew Research Centre, 2013). People in developing countries are more prone to perceive climate change as a threat, according to various studies (Godfrey et al., 2009; Pew Research Center, 2006). Climate change impacts on livelihoods can only be understood by combining and integrating knowledge from all the disciplines in accordance to studies by (Thalheimer *et al.,* 2021). Thus, we propose to expand the integration of climate data in future studies on climate change to capture impacts on livelihoods to weather and climate-related events (Thalheimer *et al.,* 2021). In order to capture the effects of weather and climate-related events on livelihoods, we advise expanding the inclusion of climate data in future studies on climate change (Thalheimer *et al.,* 2021).

Despite the fact that developing countries are the most vulnerable to climate change consequences, Pugliese and Ray (2009) found that climate change is more likely to be seen as a significant problem in developed countries than in developing countries. The Paris Agreement, signed by 195 countries in December 2015 at the UNFCCC's 21st Conference of the Parties, aimed to strengthen the global response to the threat of climate change by keeping global average temperature increases well below 2°C above pre-industrial levels and pursuing efforts to keep temperature increases to 1.5°C above pre-industrial levels (IPCC, 2018). Confronted with urgent development needs, and in response to proximate risks associated with a variable and changing climate, decision-makers in Africa must be guided by currently available climate information to make informed choices, whilst acknowledging that information availability, relevance and usability will always evolve (Chandni *et al.,* 2018).

People in Africa are notably uninformed about global climate change, despite their awareness of changing weather patterns (Godfrey et al., 2009; Taderera, 2010). The low level of climate change awareness in Sub-Saharan African countries is attributed to limited awareness campaigns on the one hand, and the fact that African countries have too many problems ranging from poverty to political conflicts on the other (UNFCCC, 2007; UNDP, 2007). As a result, climate change is never a top priority issue in the research area at the local level. The majority of Kenyans, like those in most African countries, are unaware about climate change, but are concerned about food shortages and the country's frequent droughts and floods (2009; GoK, 2010). The Kenyan government, on the other hand, is aware of climate change as a development issue and is concerned about it. The National Climate Change Response Strategy (NCCRS) – 2010 and its implementation plan, the National Climate Change Action Plan (NCCAP) 2013-2017, specifies steps to be taken to mitigate and increase resilience to the impacts of climate change.

Even when resources are gathered to combat climate change, local residents in the research area must be made aware of the situation. Increasing people's knowledge of climate change through education is a vital step in persuading people at all levels of society to take action in mitigating and adapting to the effects of climate change. As a result, Kenya is considering revising its school curricula to integrate climate change information at all levels, as the National Climate Change Adaptation Plan demonstrates (NCCA. Prior to incorporating climate change information into school curriculum, particularly at the primary school level, it is critical to

examine teachers' levels of awareness and perception of climate change, as this will likely influence how instructors transfer knowledge in the classroom. While attempts have been made to examine the amount of climate change awareness among Kenyans in general, as described in RoK (2013), GoK (2010), and Otieno *et al.,* (2009), there has been little, if any, research on the level of climate change awareness among women.

1.1.1 Global overview of climate change and livelihoods in tropical regions

Climate change affects everyone on a global, regional, and local level since pre-industrial period and its impacts are clearly discernible in the present world (UNFCCC, 2017). Climate change has affected various sectors around the world, including agriculture, forestry, energy, water resources, and biodiversity. Climate change has had a bigger negative impact on food security and livelihoods in the tropical countries (Thompson and Scoones, 2009). Several countries have devised a variety of adaptation strategies to address the effects of climate change on livelihoods, including National Adaptation Programmes of Action (NAPAs). The National Legal and Policy Framework (NLPF) and the National Climate Change Action Plan (NCCAP) are two documents that govern the country's legal and policy frameworks (NCCAP).

The greatest dangers to livelihoods are global warming and climate change, which affect human beings, food security, and natural resources, particularly in the tropics, and are intricately intertwined within the development and climate change issues of the twenty-first century (FAO, 2014). Climate change intensification will continue to affect food security especially for most vulnerable across the world. The health of the poor especially in the less developed world will be exarcerbated by climate change. Poverty is pervasive in the tropics, particularly among those who are most vulnerable to the effects of climate change (IPCC, 2014). As a result, climate change will not only increase existing hazards, but will also continue to create new ones for all systems (IPCC, 2014). Adaptation includes activities such as poverty reduction, improving access to resources and wealth, improving infrastructure, accessing decent education, improving institutional capacity, and the promotion of local indigenous knowledge, whereas livelihood has ties with climate change on all assets human capital, social capital, natural capital, physical capital, and financial capital, whereas livelihood has ties with climate change on all assets human capital, social capital, natural capital, physical capital, and financial capital, whereas adaptation includes activities such as poverty reduction, improving access to resources and wealth,

improving infrastructure (Smit *et al.,* 2001).

Most rural people and their communities in the tropical world will experience major climate impacts on food security, water availability, infrastructure, and agricultural revenue now more than ever before (IPCC, 2014). We can better understand how people's livelihoods will be affected by climate change impacts, how they will respond with the resources they have, and how these conditions can be affected and built upon successful adaption techniques by studying the dynamics of people's livelihoods (IUCN, 2004). Despite the fact that developing countries are the most vulnerable to climate change consequences, according to Pugliese and Ray (2009), climate change is more likely to be perceived as a major concern in developed countries than in developing countries (Pugliese and Ray, 2009). Even as resources are gathered to combat climate change, people must be educated on what climate change is and how to recognize evolving climate change patterns. Increasing people's knowledge of climate change through education is a vital step in persuading people at all levels of society to take action in mitigating and adapting to the effects of climate change (Pugliese and Ray, 2009).

The nutritional state of the human population is determined by the availability and quality of food, and as long as nutritional adequacy is not ensured, the body and mind's well-being will be jeopardized. Thus, damage to human assets by climate change impacts due to weather extremes such food insecurity, malnutrition, chronic hunger and undernourishment which are a rise in food prices may hurt the human population (IPCC, 2014). Today's population is faced with an increase in water shortage especially the tropical world where people live in decimated environments and high poverty levels. The poor are particularly vulnerable to the consequences of unsustainable water resources, which result in strained livelihoods (IPCC, 2014).

Because of the supporting economic resources and available information, experts from the Intergovernmental Panel on Climate Change (IPCC, 2018) agree that on the global front, investigations in the industrialized world have been done by experienced scientists. The discoveries have resulted in the creation of appropriate technology that may be utilized to minimize and adapt to the effects of climate change on livelihoods. Skeptics who do not believe in climate change science, on the other hand, have disregarded the study of renowned scientists as false, claiming that there is no such thing as climate change (IPCC, 2018). They feel that if they combat climate change, their economies would collapse and their quality of life will suffer. Despite this, climate change is still wreaking havoc on their life in some way. Floods and

wildfires have left their mark, particularly in the United States and Australia. The Intergovernmental Panel on Climate Change (IPCC) published a report in 2018 that stated. The melting of glaciers and changes in mountain river flows, as well as the disruption of plant and animal life, increased risks of avalanches, decreased snow volume, and floods in some parts of the world, have resulted in the outbreak of diseases and a surge of new disasters that have displaced millions of people. At annual COP conferences, all nations and governments must reach an agreement to help address the effects of climate change.

To embrace green technology is must in order for man to compensate for habitat loss and environmental degradation (IPCC, 2018). It is to transition away from an over-reliance on non-renewable energy sources and toward renewable energy sources, which are more efficient because they do not create greenhouse gases. Climate change's effects on livelihoods are a possible threat to communities' survival. Livelihoods can be transformed in the research area by empowering the smallholder farmer to produce more food at household level to feed family members. To be able to do this, the smallholder farmer should apply smart agriculture. The developed global economies have a head start in developing technologies to adapt to and reduce the effects of climate change due to their preparedness as a result of completed research (IPCC, 2018). As a result, it is critical to develop locally based climate change knowledge that communities can easily comprehend and apply to deal with climatic unpredictability (Mbah *et al.,* 2021). Because of the critical significance of knowledge production in the formation and growth of customary authority, it's critical to spot biases in how this knowledge is formed (Judith *et al.,* 2020).

1.1.2 Regional overview: climate change and livelihoods in Africa

Africa is more exposed to the effects of climate change and variability than many other parts of the world. Poverty, sickness, and pockets of political instability across the continent have resulted in African society's low resilience and limited adaptive capability to climate-related shocks and pressures (Washington *et al.,* 2006). Climate change is an emerging stressor that is experienced over longer time frames via changes in climatic norms and over shorter periods via changes in the frequency and severity of extreme weather events (Kohler *et al.,* 2014). Climate change is commonly recognized to have major implications for food security and livelihoods (Thompson and Scoones 2009).

To support this analogue, the study findings in the Oyo State, South west Nigeria by Ogallah 2017 reveal that climate change impacts agricultural systems and hence livelihoods of households The incidences of erratic rainfall and increasing temperature had further complicated the already bad situation of poor crop yield experience by many smallholder farmers (Ogallah *et al.,* 2017) who depend on this climate sensitive production sector for their livelihoods (Ifejika Speranza, 2010; Bello *et al.,* 2012). This has led to farmers trying out different strategies to reduce and adapt to the negative effects of climate change, particularly in many developing countries including South Africa (Ogallah *et al.,* 2017; NEST and Woodley 2011a; NEST and Tegler, 2011b and NEST 2011c). The experience and perceptions of these smallholder farmers on the changing climate patterns also corroborate the findings from the meteorological data that established these changes in our climate (Ogallah *et al.,* 2017).

Extreme droughts have already hampered people's capacity to cultivate food and raise cattle in Sub-Saharan Africa, and pastoralists and agro-pastoralists will need to adjust to changing water regimes in order to maintain their food security and well-being (Kebede *et al.,* 2011; Songok *et al.,* 2011). Impact studies are useful for determining how long-term changes in climatic norms may affect yields and food supply (Lobell *et al.,* 2008; Thornton *et al.,* 2011). According to such studies, East Africa will have wetter weather, whereas Southeast Africa will grow drier in Sub-Saharan Africa (Kotir 2011).

Droughts in Sub-Saharan Africa have already impacted people's ability to farm food and raise cattle, and pastoralists and agro-pastoralists will need to adapt to changing water regimes in order to maintain their food security and well-being (Kebede *et al.,* 2011; Songok *et al.,* 2011). Impact studies are helpful in assessing how long-term changes in climatic standards might affect harvests and food supplies (Lobell *et al.,* 2008; Thornton *et al.,* 2011). According to these studies, East Africa will experience wetter weather, whereas Southeast Africa will experience drier conditions in Sub-Saharan Africa (Kotir 2011).

Codjoe and Owusu (2011) create a food systems framework based on Rakodi's (2002) livelihoods approach to examine the impacts of climate change on the three pillars of food security and find areas for adaptation in Africa. While there are other pressures, climate change is the most important factor to address. Many African countries are already seeing changes in rainfall patterns, which are predicted to put a strain on agricultural productivity and, as a result,

have a negative influence on food security. The length of the growth season may be shortened as a result of rising temperatures. What is clear is that food production will decline in the future as a result of climate change, with total agricultural productivity possibly falling by 90% by 2100 (Boko *et al.,* 2007). Small-scale farmers are anticipated to be the hardest hit by revenue reductions due to their limited adaptive capacity (Boko *et al.,* 2007). Water stress will undoubtedly be a major concern for countries already impacted by climate change, with numerous other forecasts that, even under current conditions, reach the boundaries of their usable resources before 2015 (Boko *et al.,* 2007).

Increased water stress will have a negative impact on Africa's ecosystems (forests, grasslands, and marine) that rely on water resources for survival, with changes already being detected in some parts of the continent. Water stress will definitely be a big issue for countries that are already stressed by climate change impacts, with several other projections that exceed the limits (Boko *et al.,* 2007). People in Africa are notably uninformed about global climate change, despite their awareness of changing weather patterns (Godfrey *et al.,* 2009; Taderera, 2010). Climate change awareness is low in Sub-Saharan African countries due to limited awareness campaigns on the one hand, and the fact that African countries have too many problems ranging from poverty to political conflicts on the other (UNFCCC, 2007; UNDP, 2007). As a result, climate change is never a priority issue. African society has a poor resilience and limited adaptation capability to climate-related shocks and stresses due to widespread poverty, a large illness load, and pockets of political instability across the continent.

1.1.3 Local overview: climate change and livelihoods in Kenya

In terms of the local evaluation, climate change has increased the frequency and scale of extreme events in Kenya, resulting in deaths, lost livelihoods, reduced crop and livestock production, and infrastructure damage, among other things (NCCAP, 2013). For example, in March and May 2018, the country was hit by torrential rain and severe flooding, wreaking havoc on towns already reeling from a prolonged drought. Climate change is anticipated to have a negative impact on Kenya's future socioeconomic growth and undercut Kenya Vision 2030's ambitions. The government's Big Four program for 2018-2022 includes a long-term development blueprint that focuses on guaranteeing food and nutrition security, inexpensiveand quality housing, increasing manufacturing, and affordable health care (NCCAP, 2013). Kenya's climate is already shifting, with temperature rises recorded in all seasons, especiallyin March and May.

While total rainfall remains low, the long seasonal rains have gotten shorter and drier, and the short rainy season (OND) has been longer and wetter. Long rains have decreased in recent decades, while droughts have grown longer. NCCAP (National Center for Community Action, 2018). According to IPCC forecasts, precipitation is more uncertain than temperature projections, implying that Kenya will have a wetter climate with longer rainy seasons and less severe droughts by the end of the twenty-first century. Model studies also show that themajority of the country, particularly portions of northern Kenya that have been hit by prolongeddroughts, will dry out (NCCAP, 2018).

Kenyans have limited adaptive capacity and most of them entrenched in deepened poverty. According to (NCCAP, 2018), most do not understand what it meant by climate change because of their low literacy levels and lack of climate knowledge NCCAP (2018). Climate change will impact livelihoods by disrupting crop and livestock production in the country. The climate information obtained during such time was be complemented by exposing survey questionnaires to headsof households and informant interviewees. Very often this is not done by researchers and it may result in findings which are non-credible and fictitious. A dialogue meeting should be set out for that stakeholder from the study area to fully discuss the concept of the study. During the discussion, policy agenda was formulated to kick start the whole research process. At theend of the research process, a validation process was carried out to ascertain or give back the results to the participants or actors. This was done in an open plenary without acting behind the scenes. Therefore, research preparedness was granted top priority before the start of the research process begun. This is a weakness that is associated with many researchers because they do not prepare adequately before the start of the whole research process (NCCAP, 2018).

Kenya's climate change response strategy, according to a report by the National Climate Change Climate Response Strategy, the average maximum and minimum temperatures have increased significantly all over the country. This has significantly affected the drought period which is generally experienced between the Months of December and February each year (GoK, 2010). Changes in climate patterns are affecting food security, pasture availability and general land use. Climate change impacts on livelihood were already being felt in the study area even before this study research, and they had resulted in threats to livelihoods and reduction of ecosystem resources andservices. Rivers have had their water volume lowered due to increased evaporation

and poor land-use practices (GoK, 2010).

As a result of ecological deterioration and population growth, agricultural land, for example, had substantially shrunk in area and productivity. The national and local governments should build research and data gathering capability, as well as meteorological infrastructure, to monitor climate change impacts and devise and implement policies to safeguard natural resources and hence livelihoods. Agricultural land, for example, had declined in size and productivity as a result of environmental degradation and population growth. National andlocal governments should invest in research and data collection capabilities, as well as meteorological infrastructure, in order to monitor climate change consequences and develop and implement policies to protect natural resources and hence livelihoods.

In this regard, Kenya will continue to face the impacts of climate change in the future no matter the situation. As a country, Kenya has very little to do about the changing climatic patterns (Kaati, 2010). Under the recommendations of the Conferences of Parties (CoPs) that meet yearly under the auspices of the United Nations Framework Convention on Climate Change, this country can still mitigate and adapt to changing climatic conditions (UNFCCC). This is because climate change is a global issue that necessitates a global response, despite Kenya's participation in international initiatives (NCCAP) 2018).

The Paris Agreement under the UNFCCC aims at strengthening the global response to the threat of climate change by keeping global temperature rise this century well below 2C above pre-industrial levels. Kenya’s National Determined Contributions (NDC) sets out the country’s actions to contribute to achieving the global goal set out in the Paris Agreement that includes mitigation and adaptation contribution. The Paris Agreement under the UNFCCC aims at strengthening the global response to the threat of climate change by keeping global temperature rise this century well below 2C above pre-industrial levels. Kenya’s National Determined Contributions (NDC) sets out the country’s actions to contribute to achieving the global goal set out in the Paris Agreement that includes mitigation and adaptation contribution.

To address climate change on the domestic level, a regulatory framework consisting of laws, policies, programs, and institutions is being gradually built at the national and county levels. The Kenyan Constitution (2010) establishes the institutional framework for dealing with climate change (NCCAP, 2018). The Climate Change Act (2016), which is the legal foundation

of the NCCAP, is the fundamental legislation directing Kenya's climate change response through mainstreaming climate change into sector functions. Kenya has also developed the National Climate Change Response Strategy (2010), the first (2013-2917), the National Adaptation Plan (NAP 2015-2030), the Kenya Climate Smart Agriculture Strategy (2017-2026), the Climate Risk Management Framework (2017), the National Climate Change Policy (2018), and the National Climate Finance Policy (2018), among other sector plans and policies that address climate change concerns (NCCAP, 2018).

It is important that the citizens of this country be sensitized and involved to adapt to climate change vagaries by improving on the unsuitable land use practices that can yield positive results to achieve food security to improve livelihoods. Locals should be involved in the development of appropriate technology, such as water harvesting, climate information services, and clean cooking technologies, to deliver on adaptation and mitigation efforts (NCCAP, 2018). To achieve this vision, the entire management of the socio-economic which seems to be a mirage to small-scale farmers should be overcome by accessing climate. There is also need to set-up incentives for farmers so they can improve on the planning and management of impacts of climate change on livelihoods (Kaati, 2010).

1.2 Statement of the problem

Climate change is quickly becoming one of the most pressing international development issues of the twenty-first century. The Inter-Governmental Panel on Climate Change has recognized Africa as one of the most sensitive to climate change and variability in the region, despite its low adaptive capacity. Despite the fact that Africa is the region most likely to be affected by climate change, it contributes the least to global warming (IPCC 2007). Human activities are affecting the climate system, according to the Inter-Governmental Panel on Climate Change (IPCC, 2007), and global temperatures are expected to rise by 1.4 to 5 degrees Celsius between 1900 and 2100 as rainfall becomes more unpredictable and intense in some regions of the world.

Mountains provide a unique setting for detecting climate change and assessing its consequences (World Bank, 2008). The two most important climate-related parameters that affect livelihoods are temperature and rainfall variability (Beniston, 2003). According to new research, climate change will be more pronounced in high-elevation mountain ranges, which are warming faster

than the plains nearby (World Bank, 2008). Agriculture, human health, animal raising, tree planting, deforestation, agricultural product marketing, and household income of region people will all be impacted by climate change (Amwata *et al.,* 2015). Anthropogenic activities, such as the exponential increase in human population, have compounded the hazards to livelihoods in the studied region. Income, unemployment, illiteracy, and malnutrition are all signs of vulnerability (Amwata *et al.,* 2015).

The upper forested Mt. Elgon Ecosystem (MEE) today witnesses accelerated environmental degradation and loss of natural resources particularly water pollution, forests and soils. Due to their incapacity to cope with the physical human socio-economic repercussions of climate extremes, people living in rural areas are believed to be the most susceptible and vulnerable to climate change. Because of the exponential population growth rate, household land has been divided into small subunits, resulting in low productivity (GoK, 2014). What is now clear is that the existing land can only support subsistence food production for family members, with any remaining farm output sold to supplement income.

Knowledge management refers to the organization and sharing of climate change experiences. It is the duty of the National Governments to integrate climate change into the national school curricula at all levels of learning including primary, secondary and tertiary institutions. Furthermore, merging indigenous knowledge with formal research offers unique opportunity for vulnerable populations to mitigate and adapt to climate shocks. It is critical to develop locally based climate change knowledge that communities can easily comprehend and apply to deal with climatic unpredictability (Mbah *et al.,* 2021). Because of the critical significance of knowledge production in the formation and growth of customary authority, it's critical to spot biases in how this knowledge is formed (Judith *et al.,* 2020).

This study will contribute to closing the knowledge gap by considerably raising the adaptive ability and increasing the resilience of communities in the study area, resulting in improved livelihoods and long-term development (GoK, 2014). The climate change research community has produced data for why the poor are more sensitive to climate change and vulnerability, but less is understood about building and strengthening resilience (Leichenko *et al.,* 2014). Additional research on adaptive strategies and on how individuals can bounce back and respond to vagaries are critical for climate events and stresses (Leichenko *et al.,* 2014).

Residents in the area are facing risks to their livelihoods and rising poverty levels, and this study looks at the effects of climate change on livelihoods. Despite the various livelihood problems e.g. food insecurity, low agricultural productivity livestock production andabstraction of water resources in the region coupled with weak adaptive policies and strategies, climate change impacts assessments have not been frequently tested (Ongugo *et al.,* 2008).
As a result, a trans-disciplinary research strategy is needed to examine the state of livelihoods in the region as a result of climate change and unpredictability. People who live near forest ecosystems rely on the use of accessible forest products for their livelihoods (Appiah, 2009; Asamoah, 2007). Climate change poses a special threat to those who live in this mountain ecosystem. As a result, they are vulnerable to harsh weather occurrences as well as pervasive poverty (Macchi, 2011).

In a separate research conducted in eastern Uganda, which included a portion of Mt. Elgon, it was discovered that over 90% of households attempted to adapt their farming practices in response to climate change and variability (Knsiime, 2012). Government agencies in charge of enforcing environmental rules, including adaption technology, are underfunded and unlikely to respond to climate change's whims (KRC, 2012). Smaller holder farmers should plant high yielding and drought resistant crop varieties, practice agroforestry, practice crop rotation, ensure water use efficient technologies, access climate information and early warning systems, cultivate diversified native species, and integrate traditional and scientific tetralogies to mitigate the negative effects of climate change and variability on livelihoods (Olago *et al.,* 2014).

Since climate change is the most pressing public policy issue of our day, education plays a critical role in promoting awareness and assisting individuals, society, and governments in making informed decisions (Prapaland, 2009). Education is essential for promoting long-term climate change adaptation techniques, and analysing the levels of education in any affected community aids in the design of mechanisms for successful transmission of the necessary climatic knowledge for long-term development (Ingty and Bawa, 2012). The higher one's educational attainment, the better one's chances of understanding and implementing environmental regulations, as well as the greater one's possibilities of innovating better climate change adaptation and response mechanisms. Education can be formal or informal, and it allows communities to have access to external knowledge for better learning and decision- making.

Acquisition of a decent education must be kept in mind when developing and implementing adaptation and mitigation methods, both in terms of local perceived responses and traditional systems (Ingty and Bawa, 2012).

It is critical to design solutions to cope with the evolving circumstances, given the variations and changes in climatic systems that have resulted in catastrophic and disastrous consequences. As a result, there has been a strong push to adapt to climate change. Adaptation is the process of making changes in natural or human systems in response to present or anticipated climatic stimuli or their consequences, with the goal of minimizing harm and maximizing benefits. Vulnerability and adaptable capacity are two factors in adaptation. Vulnerability to climate change refers to the human and ecological systems' proclivity to be harmed by climate change and their ability to respond to stresses imposed as a result of the effects of climate change (IPCC 2007).

Floods, droughts, and landslides are examples of stressors. Resilience is a term used to describe the ability to respond to stress. Adaptation to climate change occurs when changes in the climate and accompanying extreme weather events are seen or projected, and adjustments are made to minimize vulnerability or increase resilience. This can be done by individuals, groups, or the entire country, such as a family planting a woodlot. To limit the number of trees cut down, the community may choose to employ energy-efficient stoves. Adaptive capacity, on the other hand, is a system's ability or potential to respond successfullyto climate change unpredictability and change, which includes changes in behaviour, resources, and technologies.

Rural livelihoods are frequently subjected to multiple shocks and stresses that are likely to increase household vulnerability. The negative impacts associated with climate variability and change are further compounded by many other factors, including widespread poverty, human diseases, and high population density, the last estimated to double the demand for food, water and forage within the next years to come (WWF, 2006). Individuals and communities in rural areas must cope with and adapt to a variety of pressures, including climate unpredictability and change. Households and communities have devised clever strategies to adapt to varied degrees of harsh weather occurrences for decades. Climatic science has provided an indication of how to analyze rainfall trends across years, and has thus been deemed a tool that could help plan for and/or adapt to climate variability and change, particularly in terms of seasonal forecasting

(Ziervogel and Calder, 2003). Demand for information and confidence in many parts of Africa sometimes surpasses what climate scientists can realistically achieve (Conway, 2011), and this may extend to other regions, particularly mountainous places. As a result, adaption techniques may be developed without sufficient evidence-based data (Taylor *et al.,* 2013).

Given the variations and changes in climatic systems that have had catastrophic and terrible effects, it is imperative to build ways to deal with the changing situations. There has so been a significant drive to adapt to climate change. In order to minimize harm and maximize benefits, adaptation is the process of making adjustments to natural or human systems in response to current or projected climatic stressors or their consequences. Two aspects of adaptation are vulnerability and adaptability. The ability of ecological and human systems to withstand pressures brought on by climate change's effects and their propensity to be injured by it are referred to as vulnerability to climate change (IPCC 2007). Stressors include things like landslides, floods, and droughts.

The capacity to react to stress is referred to as resilience. Changes in the climate and related phenomena lead to adaptation to climate change. Stressors include things like landslides, floods, and droughts. The capacity to react to stress is referred toas resilience. When changes in the climate and associated extreme weather events are observedor expected, adaptation to climate change takes place when changes are undertaken to reduce vulnerability or boost resilience. Individuals, teams, or the entire nation can carry out this action, such as when a family plants a wooded area. The neighborhood may decide to use energy-efficient stoves in order to reduce the amount of trees felled. The ability or potential of a system to successfully adapt to climate change-related variability and change, including adjustments to behavior, resources, and technologies, is known as adaptive capacity.

1.3 Objectives

1.3.1 The main objective

The main objective of the study was to assess the sustainability of livelihoods impacted by assessment of climate change and make robust policy recommendations to improve livelihoods and sustainable development in Kapsokwony Division, Mt Elgon District in Kenya.

1.3.2 Specific objectives

The specific goals of the study were:

- Analysis of 30 years historical climate change data for trends, variability andperceptions of the local community from the period 1986-2015;
- To establish the extent to which climatic change and variability has impacted livelihoods in Kapsokwony Division, Mt. Elgon; and
- To establish the coping and adaptation mechanisms employed by households in response to the consequences of climate change and variability.

1.4 Justification and significance of the research

1.4.1 Justification

Climate change unpredictability have increased environmental deterioration and natural capital loss in the study area in recent years. Crop and livestock output have been impacted in recent decades by changes in precipitation and patterns, as well as temperature variations (Sindani, 2013). Many variables, including widespread poverty, human diseases, high population density, which is expected to increase food demand in the next few years, a lack of safe drinking water, and poor animal raising, exacerbate the negative effects of climate change. Due to low economic resources and reliance on rain-fed agriculture, the region's farmers have little adaptation capacity (Sindani, 2013).

Agricultural systems and livestock rearing are the mainstays of rural livelihoods in the study area. However, as a result of climate change, rainfall patterns have become more variable, unreliable, and unpredictable in recent years. The reduction in amounts of precipitation has resulted in inadequate soil moisture leading to decreased crop production and decreased pasture (Amwata *et al.,* 2015). The situation has further been exacerbated by enhanced temperatures in the last three decades. A paradigm shift in the rainfall patterns has made the farmers to wait longer than usual before planting. There is a danger of food insecurity, hunger, and a rise in poverty levels as a result of climate change (Amwata *et al.,* 2015).

As a result, the current research aims to mitigate the detrimental effects of climate change on

livelihoods, which are expected to grow in the future. Environmental degradation and dramatic weather changes entail socio-economic burdens, aswell as increased competition and the risk of resource conflict. In order to sustain and improve livelihoods, proper land use planning and efficient use of natural resources are required. Climate change appears to be causing significant weather changes in Africa's mountain ecosystems (IPCC, 2007; 2014). Just like elsewhere in the world, there is a significant relationship between the mountain ecological zones and the people who reside near Mt. Elgon ecosystem.

Variation in vulnerability and adaptive capacity exist, based on livelihood options available at household levels, access to resources for all and climate information in this part of the World just like in other parts**.** Within communities that reside in the study area, variations approaches to livelihoods are varying depending on the available opportunities and adaptive strategies used at household levels for daily requirements. Limited access to information and low literacy levels in the region are some of the limiting factors that enhance poverty levels in Mt. Elgon (World Bank, 2008). New and improved adaptive techniques and policies are needed to address climate change's unpredictable effects while still sustaining socioeconomic development in communities near the Mt. Elgon habitat.

Choices made now and in the future years about emissions will have far-reaching implications for climate change impacts. Impacts are projected to become increasingly severe for more people, particularly in Africa, unless the pace of emissions is significantly lowered. Similarly, decisions must be taken about adaptation measures that can help to mitigate or avoid some of climate change's negative consequences. The adaptation strategies cannot be applied uniformly all over the region because of the variations of how livelihoods are impacted from one part of Africa to another. However, research into the effects of climate change on livelihoods necessitates an interdisciplinary approach, which is currently lacking. There's still a lot to learn about the efficiency of different sorts of adaptation responses, as well as how they'll interact with one another and mitigation measures. As society learns by doing, responses to the climate change dilemma will very certainly vary over time. It will be an iterative process including scientists, policymakers, and public and private decision makers at all levels to determine and refine society solutions. Implementing these response tactics will necessitate careful planning and ongoing feedback from government, industry, and society on the effects of mitigation and adaptation policies. The lack of information is critical for reducing and adapting to the effects

of climate change on African livelihoods. As a result, this research serves as an endeavor with the goal of successfully and significantly contributing to the vast climate data in order to close the knowledge gap.

1.4.2 Significance

People in the research region are thought to be the most vulnerable and sensitive to climate change due to their incapacity to cope with the physical, socioeconomic, and psychological repercussions of climate extremes, as well as their low resilience. The research looked at historical climate data and how it affected agricultural practices and lifestyles. Climate-related stressors are compounded by a slew of structural weaknesses, including high poverty, fast population expansion, increased strain on natural resources, limited livelihood possibilities, and low educational attainment. At the conclusion of the study, policy suggestions were developed to strengthen the region's adaptive ability and resilience. This research study aided all stakeholders in developing a policy framework for climate change mitigation and adaptation for current and future residents of the study area.

Increased climate stressors at household level may result in livelihood shocks that may hurt and make households' slide into chronic poverty. The findings of this study will provide a forum for dialogue and engagement among different stakeholders including planners, policy makers, rural dwellers to minimize conflicting perceptions and concerns. Through research new policies and adaptive strategies will be designed and pragmatically rolled out with an aim of improving livelihoods and sustaining development (GoK, 2012). For instance, this research will help the researchers develop a resilience framework for climate change adaptation and mitigation in the study area. This assessment will generate new transformation knowledge which will be used to develop the state-of-the-art solutions to resolve societal problems and new adaptive policies to demonstrate preparedness for a changing climate in the region.

1.5 Scope of the research

The researchers also wanted to know how communities deal with and adapt to the negative effects of climate change and variability. This study did not encompass all the ecosystems of Mount Elgon, and was restricted to the peculiar livelihoods of the residents of Kapsokwony Division, Mt. Elgon District. Climate data and information was restricted to rainfall and

temperatures trends from 1986 to 2015. The livelihood aspects which were investigated were agricultural activities, livestock keeping and agribusiness. Thus, other livelihood aspects such as water quantity and quality, access to markets for food products were not addressed in this study.

The project's primary goal was to put in place transformation knowledge that local residents could access and use for critical informed decision making to better their living conditions. The impacts of climate change on people's livelihoods were evaluated in relation to weather rainfall and temperature variations. In order to protect and improve livelihoods, this research focused on long-term strategies. Dialogue and cooperation of the personal opinions of all stakeholders during interviews, discussions, conferences and seminars were elucidated during research. The predicted responses were designed to boost long-term adaptive policies and ecosystem production while fostering resilience as part of adaptation efforts, particularly for such vulnerable communities (Tompkins *et al.,* 2004; Reid *et al.,* WRI *et al.,* 2008).

1.6 Limitations of the research

Small samples compromise the research's internal and external validity, whereas big samples tend to turn little variations into statistically significant conclusions, even if they are clinically unimportant. For instance, in the present study, I managed only three FGDs, twelve KIIs and three ninety-eight household survey questionnaires. The sample size was also limiting because the population comprised people of varied profiles.

Both qualitative and quantitative data collection methods were used. Because it involves the collecting of data / information through open-ended and conversational contact, qualitative research is not statistically representative. For instance, the results of the qualitative research could not be verified and the whole process was labour intensive.

Scanty literature is evident of the fact that no research had been carried out by other researchers as concerns the sustainability of climate change on livelihoods in the study area. The lack of climate change data in the region is a source of uncertainty in future climate change studies, particularly in mountainous areas.

Money as a resource is always a limitation to research because it is required for adequate preparations that include putting the inter-disciplinary research team in place, purchase of

equipment, travelling to and fro, provision of meals, out of pocket pay to members of the research team and dissemination of results. Another major impediment to the present research was the language barrier as a limitation. This problem was overcome by engaging the enumerators from the communities residing in the region and the village elder to help interpret the questions put across to respondents. In order to overcome this particular limitation, I recruited and engaged members of the research team from the communities which live in the research area who speak the native languages. The difficulty of balancing technology that would be advantageous under current climateconditions with those that are more adaptive under future climate conditions to increase resilience is another constraint of research.

Scientific innovations may be ineffectual or even detrimental in the face of a changing climate if they are not properly used (Biagini *et al.,* 2014). Finally, another important knowledge gap worth mentioning during this research was the fact that the policy actions can be in-effective to existing adaptation measures. It's also unclear when adaptation should take place, as waiting until more knowledge is known may be a better strategy for some people to respond successfully to climatic exposures or whims (Smit and Pilifosova, 2001).

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Climate change is defined as a shift in weather patterns such as temperature, precipitation, and wind through time, which can range from months to millions of years. 30 years is the traditional time frame used in climate change research (Hannah *et al.,* 2005). Natural and manmade factors are both blamed for climate change (IPCC, 1996, 2007). Natural phenomena such as solar fluctuations and volcano eruptions occur independently of human intervention. Human activities or human-induced drivers that create changes in the Earth's atmosphere are known as anthropogenic causes. Climate change and variability can both be attributed to changes in regular climatic patterns over long and short periods of time, respectively. It can also be defined to mean the change from one mode of climate to another mode which takes or may take hundreds or thousands of years to occur (IPCC, 2007a). Climate change and variability have a considerable detrimental impact on agricultural productivity, environmental degradation, and thus ecosystem service changes. Any increase in global average temperature exceeding 1.5°C - 2.5°C, according to IPCC (2007b), is projected to cause significant changes in the structure and function of ecosystems, negatively affecting livelihoods, well-being, and socio-economic development.

It is estimated that the livelihoods of 70 % of Africans are dependent on rain-fed agriculture, an activity that is characterized by small-scale, subsistence farms that are vulnerable to a variety of stresses, including those associated with climate change (Challinor *et al.,* 2007; World Bank 2009). Due to its largely adverse effects on African agriculture and livelihoods, climate change is expected to have a negative impact on food security (Niang *et al*., 2014; Challinor *et al.,* 2007; Thornton *et al.* 2011).

Due to their low adaptive capability and reliance on climate-sensitive rain-fed agriculture, smallholder subsistence farmers are among the hardest affected by climate change (Ifejika, 2010; Easterling, 2007). Because the poor are the most vulnerable to the effects of climate change and unpredictability, the climate change research community must be intimately involved in the production of transformation knowledge. However, little is known about elements that promote and strengthen resilience (Leichenko *et al.,* 2014). The collaboration

among stakeholders on innovative adaptive measures is a collective action and should call for sharing of knowledge and information on climate change impacts on livelihoods. Collaboration with the local institutions should be put at the front to breach the gap and foster experience on innovative measures of improved food security as a result of climate change (GoK, 2015).

In light of this, collaborations with the developmental partners are a good thing because they have the expertise, knowledge, resources and this can lead to innovative ways to adapting to climate change vagaries. Lack of adequate research and collaboration directly affects performance of systems including new innovations and technologies (GoK, 2015). Traditional knowledge about people's livelihoods, such as weather and climate, suggests that knowledge passed down through generations is still used today, but it can be supplemented with scientific knowledge, potentially fostering changes that would not be associated with climate change and variability alone (Wolf *et al.,* 2011). In general, climate change has severe negative effects on livelihoods and the natural environment, including ecosystem destruction. Mt. Elgon Ecosystem (MEE) is one of the hotspots of climate change and variability because the region is especially vulnerableto several influences of floods, prolonged droughts, degradation of surface water resources and declining crop yields (NACCP, 2014).

Any increase in global average temperature exceeding 1.5°C - 2.5°C is predicted to cause significant changes in ecosystem structure, function, and geographical ranges, severely affecting species distribution and survival (IPCC, 2014). Whenit comes to studying the effects of climate change on livelihoods, trend and variability analysis of meteorological factors such as rainfall and temperature are the most useful. This can have an impact on communities' socio-economic status, stymie progress toward development goals, and pose a general danger to long-term development in developing countries that are more reliant on natural resources and rain-fed agriculture (IPCC, 2007). The Kenya Government has drawn up a progressive document (NCCAP, 2018) that lays out strategies to combat this phenomenon. One of the ways, for example, is to promote and empower individuals through people-cantered development to guarantee that climate change initiatives contribute to the country's long-term goals. One of the ways, for example, is to promote and empower individuals through people-cantered development to guarantee that climate change initiatives contribute to the country's long-term goals.

2.2 Mountain ecosystems and climate change

Climate change and its interactions with other anthropogenic stresses including as encroachment, land fragmentation, degradation, and destruction of natural resources are currently affecting mountain ecosystems all over the world. Changes in temperature, exposure to extreme events, and accessibility to nourishment, air quality, and disease vectors will all have an impacton human health as a result of climate change (IPCC, 2007). Losses in agricultural production, for example, in the Eastern Himalaya countries may result in increasing malnutrition and fewer opportunities to reduce poverty. Climate change will diminish earnings and opportunities for vulnerable communities in general. The combined consequences of climate factors and their interactions with other anthropogenic stressors such as encroachment, land fragmentation, degradation, and destruction of natural habitats are now affecting mountain ecosystems all over the world (Mano and Nhemachena, 2007; Biggs *et al.,* 2008; Amwata, 2013).

Climate change could have a severe impact on subsistence farmers and pastoral peoples, who make up a substantial section of the rural population, according to studies on livelihoods in the Eastern Himalaya (EH) highlands. The sphere of agricultural production is one of the most serious areas of serious influence. Agriculture is a direct or indirect source of income for approximately 70% of the population in the EH and contributes significantly to national incomes. (Fischer *et al.,* 2002a). Agriculture is extremely vulnerable to climate change, and it is predicted to have a distinct influence on the region, with some changes in precipitation patterns. Impacts on livelihoods in the Eastern Himalayas, according to IPCC forecasts, show that precipitation will most certainly decrease in the future. In the EH, Climate Change Impact and Vulnerability (CCIV), there will be a decrease in potentially good agricultural land, while others will gain from significant increases in acceptable regions and production potentials (Fischer *et al.,* 2002).

Several studies have revealed that rice, corn, and wheat production has decreased as a result of increased water stress caused by rising temperatures, increased *El Nino* frequency, and a decrease in the number of rainy days (Agarwal *et al.,* 2000; Jin *et al.,* 2001; Fischer *et al.,* 2002b; Tao *et al.,* 2004). Climate change is expected to erode poor people's livelihood assets, disrupt the route and rate of national economic growth, and jeopardize regional food security. According

to a World Bank report on climate change, upland areas are warming faster than lowland areas (World Bank, 2008). An increase in temperature of 1.5°C to 2.5°C is predictedto cause considerable environmental damage, negatively harming livelihoods and humanity's survival. People's livelihoods in underdeveloped nations are heavily reliant on natural resource bases, affecting community socioeconomic status while also impeding progress toward development goals (IPCC, 2007a). Together, climate and non-climatic stressors may have considerable impacts on the ecosystem's functions and services (Lovejoy *et al.,* 2005).

Climate change has a significant impact on forests. Kenya's forest cover, which includes both indigenous and plantation forests, is estimated to be 1.5 percent. The Mt. Elgon water tower is one of the country's key water catchment regions. Forest degradation has caused significant destruction, reducing forest canopy cover and increasing Green House Green emissions (GHGs). Environmental degradation is caused by human activities, especially unregulatedforest products removal by companies and communities. Changing climatic circumstanceshave also had an impact on the rate of regeneration, particularly in natural forests. This has an impact on the ecological services that forests supply, such as soil erosion reduction, natural insect management, water availability preservation, and water quality maintenance (KFS, 2014).

Africa is the continent most exposed to climate change and variability (IPCC, 2007). Projected rainfall changes for period 2016-2035 can be up to 20% relative to reference period 1986-2005 whereas surface temperatures can be greater than 0.5°C per decade for interior regions (Kirtman *et al.,* 2013). Rainfall, temperature, humidity, and flooding are the factors that havethe greatest impact on the spread of malaria, cholera, diarrhoea, kala-azar, and dengue fever; climate change will have an impact on all of these (IPCC, 2007). Future precipitation forecasts imply a strong possibility of rises in higher latitudes and declines in subtropical regions,according to data recorded by the (IPCC, 2007). It is predicted that rising greenhouse gas concentrations will cause various changes in the global climate system in the twenty-first century that will be more significant than those seen in the previous century (IPCC, 2007). This might have serious implications for the survival of natural environmental ecosystems, many of which are already suffering from the effects of climate change (IPCC, 2007).

2.3 Sustainability of livelihoods impacted by climate change

For a long time, people who live in the study area which is adjacent to Mt. Elgon Forest depend

directly or indirectly on the forest natural resources for survival (GoK, 2014). Nature can exist in productive harmony, allowing for the social, economic, and other fulfillments of present and future generations, in order to maintain the sustainability of livelihoods and establish the essential conditions under mankind (GoK, 2014). The concept of objective and target sustainability formed the UN's thinking, which asks for a reasonable quality of living for everyone today without jeopardizing future generations' needs (UN Rio+20, 2013). However, achieving these targets and goals will necessitate the finding of effective methods for assisting the poor in rising out of poverty and obtaining respectable work while minimizing environmental damage. It also necessitates the distribution of renewable energy to everybody while ensuring that this does not contribute to climate change. It is for this reason that adaptation to climate change will require sustained funding (UNFCCC, 2014) by industrialized countries to help support climate adaptation in less developed countries.

2.3.1 Climate change and agriculture

The people who live in the study region rely on cropping systems and livestock rearing as their main sources of income. Agricultural activities, on the other hand, are the economic sectors most exposed to the effects of climate change and variability. Climate change has had serious consequences for the natural environment, including changes in ecosystem services. (IPCC, 2007). This can have an influence on communities' socio-economic status, stymie progress toward development goals, and pose a general danger to sustainable development in emerging countries with a higher reliance on natural resource-based livelihoods (IPCC, 2014). Climate and non-climatic stresses may have a significant impact on ecosystem functioning and services when combined (IPCC, 2014).

According to (IPCC, 2007) Africa is the continent most vulnerable to climate change and variability. Projected rainfall changes for period 2006-2015 can be up to 20% relative to reference period 1986-2015 whereas surface temperatures can be greater than 0.5°C per decade for interior regions (Kirtman *et al.,* 2013). Rainfall, temperature, humidity, and flooding are the factors that have the greatest impact on the spread of malaria, cholera, diarrhoea, kala-azar, and dengue fever; climate change will have an impact on all of these (IPCC, 2012).

There is a manifestation of a long-term decline in MAM rainfall totals in East Africa (Lyon and DeWitt, 2012; Viste *et al.,* 2013; and Liebmann *et al.,* 2014), leading to devastating droughts

that result in famine and population displacement affecting millions of people (Lyon and DeWitt, 2012; Viste *et al.,* 2013; and Liebmann *et al.,* 2014). The Indian Ocean, according to William and Funk (2011), is the key driver, whereas (Lyon and DeWitt 2012; Lyon 2014; Yang *et al.,* 2014) suggests a *La Nina* like pattern is of primary importance. The East African climate the contradiction can be explained using natural climate variability, human gas emissions, and possibly the land use theory. (2014) and Yang *et al.,* (2014) conclude that the decline of MAM and increase in OND is due to natural variability and a possibility of anthropogenic emissions as well as land use changes.

Farmers and other resource users in the Sahel (Mertz *et al.,* 2009) and the Nile Basin (N.B.) of Ethiopia (Deressa *et al.,* 2008) share a consistent sense of climate change indicating greater variability of rainfall and shifts in the growing seasons. Farmers' decisions on what crops to raise, when to plant, and other farm management methods are influenced by the seasonal distribution of rainfall (Komutunga *et al.,* 2001). Furthermore, severe rains, both in terms of intensity and duration, cause water logging, which harms crops and pasture. The numerous landslides that occurred in the hilly Eastern Uganda between 2006 and 2010 were caused by heavy rains (Komutunga *et al.,* 2001).

Livestock is extremely vulnerable to environmental changes and is already suffering from the effects of climate change. Droughts have become more common in the region, resulting in increased cattle morbidity and mortality due to a lack of feed, an increase in disease occurrences, and low productivity. The degradation of an ecosystem may increase climate vulnerability for communities that live in the ecosystem (Travers *et al.,* 2012).

Disease management remains a pressing challenge among livestock keepers in the study area due to ignorance, animal movement and open grazing systems. Animal diseases and pests contribute significantly to low productivity and lead to low income for livestock keepers. In addition, disease outbreaks impact livestock trade and the prevalent livelihoods. It is for these reasons that diseases be identified as a critical area for livestock management. Good management of livestock will enhance productivity and commercialize the livestock sector, ensuring livestock keepers earn handsomely for their efforts. New organic livestock farming which is taking the whole world by storm is the most important thing to improve livelihoods.

Livestock farming faces a bleak future because of the shrinking pasturelands, erratic rainfall,

rising temperatures, enhanced livestock diseases and population explosion. This could see a significant drop in the economy of livestock production marking lost opportunities for farmers to earn a sustainable income. However, the County government should consider the construction of a meat processing facility (an abattoir) to set up quality standards for processingas this is one of the constraints that lowers livestock production. This would improve food security, livelihoods and boost economic development (NCCAP, 2018).

2.3.2 Climate change and natural resources

Climate change and fluctuation, as well as the overuse of natural resources, exponential population increase, water resource degradation, poor cropping systems and deforestation are all key factors to consider that impact livelihoods in the region. Yields of crops such as maize, beans and potatoes on which livelihoods depend, are threatened by the changing climatic patterns. Agriculture, livestock, and fisheries, on the other hand, are some of the region's most sensitive economic sectors to climate change. Increases in surface average temperature exceeding 1.5°C are predicted to reduce agricultural production of crops including maize, beans, and potatoes (NCCAP 2018). The impact of decreased agricultural production due to irregular rainfall, rising temperatures, reduced soil productivity through erosion, and increased evapo-transpiration is extremely substantial in the research area because rain-fed subsistence agriculture sustains over 70% of rural livelihoods (NCCAP 2018).

Climate change may also be a driving force behind poor resource management, as people resort to increasingly unsustainable coping mechanisms to deal with recurring climate shocks (NCCAP, 2018). Each household's goal should be to improve agroforestry and livestock rearing (NCCAP, 2018). The water quality of rivers is greatly influenced by land use within the watershed. Changes in land cover and land management techniques have been identified as significant contributing variables in the hydrological system's alteration, which results in changes in runoff and water quality. Water is plentiful in the area, but due to poor design and management, only a few households have access to piped water. One of the biggest threats facing livelihoods is the availability of clean drinking water resource at household levels (Wilson and Weng, 2010). Due Already residents in the study area are faced with water stress on the basis of water quantity and water quality. In future water scarcity will stress food production, trigger several new diseases, worsen fuel shortages which are already strained and retard economic

development (Wilson and Weng, 2010). As temperatures rise, diseases such as malaria, Africa's leading killer, may become more prevalent in the region (NCCAP, 2018).

2.3.3 Vulnerability and climate change

The issue of vulnerability reduction can be resolved if communities living in the study area can develop a common platform to reduce climate change impacts on livelihoods. Vulnerability reduction can be achieved through activities such as decrease of climate change impacts on livelihoods, poverty reduction, effective management of natural resources and disaster risk reduction (Thornton *et al.,* 2014). Adaptive solutions applied in the research area today may be effective and durable in enhancing livelihoods and socioeconomic features, but they may be ineffective in the future due to exponential population growth and related dynamics. New adaptation techniques, such as those suggested by the study, must be included into household livelihoods in order to reduce community vulnerability. Individual behaviour changes, transformation knowledge application, and new integrated technology are all part of these measures. It is critical to choose appropriate and advantageous technologies for adaptation under current climate change conditions, as well as those that can be easily adopted in the future (Thornton *et al.,* 2014) to be taken into account in the livelihoods of households in 2.3.4

2.3.4 Diversification of livelihood sources

Diversification of livelihoods impacted by climate change is an important strategy for increasing resilience, but it must be done in a way that is informed and empowered (Gebru *et al.,* 2012). Recurrent climate shocks and strains to established livelihood choices always push the decision to diversify (Gebru *et al.,* 2012). When one approach fails, having a variety of strategies for providing food and income offers a people with options. Livelihood diversification is the process through which rural households build a portfolio of activities to support their ability to survive and improve their level of living (Ellis *et al.,* 2000).

It can also be defined as the continual maintenance and change of a wide range of activities and vocations in order to reduce household income fluctuation, mitigate seasonality's negative effects, and give employment or additional revenue (Ellis *et al.,* 2000: Barret *et al.,* 2001; Alobo 2015). Because of the population boom, rural households must diversify (Khatun *et al.,* 2016). To cope with a variety of obstacles and hazards, including as poverty and food insecurity, rural

households engage in and pursue a variety of non-farm livelihood activities (Alobo 2015; Kassie *et al.,* 2017; Gebru *et al.,* 2012). The poor households with little or no diversification options would further be pushed towards vulnerability and marginalization.Further, individuals from these households would be forced to work for well-off households as labourers to earn some income (Kassie *et al.,* 2017).

Diversification's usefulness as a method for increasing livelihood resilience may, however, be hampered in the lack of the appropriate information and assistance (Gebru *et al.,* 2012). Engaging in new non-farm activities necessitates the acquisition of new skills and knowledge, which may not be available in the community. External actors may be needed to help with capacity building and technical assistance (Gebru *et al.,* 2012). New livelihood strategies may come with new risks, which must be acknowledged in order to maintain the appropriate mix of strategies in the household portfolio. Due to exorbitant interest rates and the worry of not being able to repay, as well as a lack of collateral and entrepreneurship skills, the majority of smallholder farmers do not use loans (Gebru *et al.,* 2012).

In the study area, diversification as strategy was considered as an option and was done by a few households in the case study. The well-off homes diversified the most, while the impoverished households did not, maybe because they were too preoccupied with day-to-day issues, lacked long-term vision, and couldn't find the time. Well-being households with better access to information, technical skills, access to savings and credits had the provision for loans at times of emergency. They were able to diversify and engage in agri-businesses to earn more income in order to improve livelihoods.

Non-farm activities have the ability to assist households in reducing poverty by providing a solid hedge against the risks of farming and reducing their dependency on natural resources (Haggblade *et al.,* 2010). The increase probably produced more farm products which could be sold for the expected economic gains once the subsistence requirements have been met by the local communities and households. A spike in production can be caused by a combination of improved seed, varieties, chemical fertilizers, and excellent weather, allowing farmers to produce enough food and sell the surplus. Non-farm income accounts for 40 percent to 45 percent of typical household income in Ethiopia, according to empirical studies (Realities 2011; Bezabih 2010).

2.3.5 Decline in water quality and quantity

Kenya is a water-scarce country, with only 647 cubic meters of water available per inhabitant (m3). Climate change is anticipated to exacerbate the region's water quality and quantity issues (NCCAP, 2018). Temperature, wind speed, humidity, sun intensity at the ground, vegetation, and soil moisture all influence the proportion of precipitation that runs off during rainstorms. A changing climate will have an impact on the quality of surface water and the quantity of groundwater (Sindani, 2013). Sediments, nitrogen from agriculture, disease pathogens, pesticides, herbicides, salt, and thermal pollution will all be enhanced by observed and forecast increases in precipitation intensity ((NCCAP, 2018). Increased silt in runoff and epidemics of waterborne illnesses are caused by heavy rains. Pollution, on the other hand, has the ability to be diluted in areas with increased stream flow. Changes in water quality during the last few decades were most likely caused by factors other than climate change (Sindani, 2013). Climate change will add to the load on already overburdened water infrastructure. Water demands are likely to shift as temperatures rise, and evaporation is expected to increase across most of the region (NCCAP, 2018). Water pollution caused by anthropogenic activities can contaminate the freshwater supply, posing a public health risk. Drought will damage livelihoods due to less precipitation, higher evaporation, and increased water loss from plants (Sindani, 2013).

2.4 The effects of climate change on people's livelihoods

Agricultural systems in the research region, like in other parts of the country, are dominated by top-down, centralized, monolithic, and isolated structures (NCCAP, 2018). Linkages, collaboration and interactive learning processes are completely non-existent. This is prevented by empirical evidence between actors as several linkage gaps despite the fact that research is going on in national and international institutions. The coordination is dysfunctional and poorly linked to the productive sectors and very few research publications in peer reviewed journals are available (NCCAP, 2018). Farmers' innovations aren't included in knowledge systems because national agricultural institutions like Kenya Agricultural Livestock Research Organization (KALRO) and Kenya Plant Health Inspection Services (KEPHIS) portray research as the source of innovations (NCCAP, 2018).

The study area's rural livelihoods are primarily dependent on the resolve around farming operations. Agricultural systems are heavily reliant on changes in rainfall patterns. Changes in

rainfall patterns are anticipated to have a negative influence on rural livelihoods, which are present in the research area (NCCAP, 2018). The reduction in the amounts of precipitation will lead to inadequate soil moisture resulting in decreased crop production and reduced foliage for animals. This can further be exacerbated by enhanced surface temperatures leading to stressed crops (NCCAP, 2018). The people have noticed a change in rainfall, as demonstrated by the need to wait longer before planting. Climate information should be made available to smallholder farmers on a regular basis, ideally in vernacular languages, on radio and television stations so that they may make informed decisions about their farming activities (NCCAP, 2018).

Due to a lack of staff, there is currently relatively little training in climate change adaptation and food security (NCCAP, 2018). The inadequate manpower training in climate change and food security has an indirect impact on adaptation options available to the farmers. There is need for a well-balanced training in climate change to enhance manpower growth in order to enhance productivity to sustain and improve livelihoods (NCCAP, 2018). In order to adapt to the effects of climate change, smallholder farmers need be taught how to blend promising indigenous and scientific technologies. The interaction of researchers was critical in the development of new policy frameworks that deal with livelihood aspects such as food security (NCCAP, 2018).

The collaboration among stakeholders on innovative adaptive measures is a collective action and should call for sharing of knowledge and information. Collaboration with the local institutions should be put at the front to breach the gap and foster experience on innovative climate change mitigation and food security methods (GoK, 2015). Whatsoever, collaborations with the developmental partners is a good thing because they have the expertise, knowledge, resources and this can lead to innovative ways to adapting to climate change vagaries. Lack of adequate research and collaboration directly affects performance of systems including new innovations and technologies (GoK, 2015).

As a result of the increased possibility of intense and unpredictable weather as a result of climate change, new crop diseases are more likely to emerge, posing a danger to food securityin the research area. Future precipitation forecasts imply a strong possibility of rises in higher latitudes and declines in subtropical regions, according to data recorded by the (IPCC, 2007). Over the course of the twenty-first century, it is expected that rising greenhouse gas concentrations will pose a number of dangers to the global climate system. These dangers are projected to be greater

than those seen in the twentieth century (IPCC, 2010). This might have serious consequences for the survival of natural ecosystems, many of which are already being impacted by climate change (IPCC, 2010).

Traditional knowledge about people's environment, such as weather and climate, shows that knowledge passed down through generations is still used today, but that it can complement modern knowledge and potentially help drive changes that would otherwise be linked with variability alone (Wolf *et al.,* 2011; Amwata *et al.,* 2018). There has been very little research on the effects of climate change on livelihoods in the Mt. Elgon region. When developing adaptation techniques, it is critical to consider indigenous people's knowledge and experiences. There is very little literature on the impacts or responses of populations in the Himalayas, for example, but indigenous communities have a lot of information based on their observations. Perceptions and experiences gained over time can be used to supplement scientific knowledge in order to improve climate change mitigation and adaption measures. (Ingty *et al.,* 2012).

2.5 Coping and adaptation strategies

Individuals, communities, regions, and economies respond to changes in the size and distribution of important climatic variables such as rainfall, temperature, and evaporation by adapting to climate change (IPCC, 2007). Exposure to climate change, such as a decrease in average rainfall, and the susceptibility of individuals and communities to such changes dictate the need to adapt (IPCC, 2007). Disaster risk reduction, climate change implications on livelihoods, poverty reduction, and environmental management are all part of adaptation measures. Adaptation techniques that can be used to carry out measures that target and minimize the vulnerabilities of disadvantaged communities are successful (IPCC, 2007). Understanding adaptation capacity is primarily a social science endeavour because it focuses on people and communities, their individual and collective capabilities and actions, which vary depending on socio-economic, generational, and cultural factors, as well as the interaction with institutions and systems (Smit *et al.,* 2001). As a result, effective adaptation necessitates a thorough understanding of the physical and socioeconomic consequences, as well as an integrative approach that takes into account both human and biophysical aspects (Ribot, 2010), Interactions with institutions and social systems are also important. Climate changevulnerabilities are also connected to other stresses, according to the report (Adger *et al.,* 2007). To understand the numerous elements

affecting communities, climate adaptation necessitates both an impact analysis and a vulnerability analysis. It's also crucial to recognize that this isn't the only issue influencing human affairs (Smit *et al.,* 2001). A technology is called resilient ifit tries to increase resilience while also absorbing shocks in order to achieve long-term adaptation as well as transformation change (Biagini *et al.,* 2014).

Many additional researchers have investigated the effects of climate change and variability on Kenyan livelihoods in other ways. According to Amwoliza, increased food production employing resilience-based farming practices in a changing environment in Tharaka Nithi County, Kenya (2018) sought to investigate how historical climate data impacted household food production and their determinants. The findings of this revealed that low levels of technology use in agriculture, poor soil fertility and poor rainfall distribution as well as upward surge in land surface temperatures were responsible for poor household food security. She proposed that food security can be achieved through practices of conservation agriculture. She also proposed that the government of the day should educate the people through early warning systems about weather and climate related patterns by investing in satellite information.

Climate variability and land usage on livelihoods in Kiboko-Makueni Observatory Kenya, a related study conducted by (Amwata, 2013), found that weather shocks had a significant impact on growth performance in Kenya's low-income counties. She found out that climate changes and variability have adverse implications on household livelihoods and economic growth. Her research also discovered that in Kenya's drylands, land-use patterns live as a unit. Food is, after all, a basic necessity and a key prerequisite for a healthy and productive life, regardless of climate shocks. Furthermore, based on the findings of her research, government policies in the counties of Kajiado and Makueni should support improved livestock breeds (Amwata, 2013). Further, she also proposed that it is important to access localized climate information so that forecasting can be more accurate to provide proper guidance to design better adaptive strategies and build resilience to climate vagaries. Amwata's (2013) recommendations of agroforestry enhancement and re-afforestation to attract more rainfall and lessen temperatures as well as to apply chemical fertilizers to boost production are very much in line with recommendations of other related studies.

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in Nepal, a similar study by Narayan (2012), found that the impacts of climate change are more severe where people rely on weather-dependent rain-fed agriculture for their livelihoods. Rural mountain communities with restricted livelihood options have low adaptive ability, according to this study, due to a lack of information, inadequate access to services, and unequal access to production assets. Climate change and variability are hurting the livelihoods of mountain people in Nepal's Jumla District, as well as Kenya's Kapsokwony Division of Mt. Elgon (Narayan, 2012). Poor home communities are already impoverished as a result of resource depletion, food scarcity, a lack of essential services, and rising social inequities.

2.6 Summary

According to the IPCC (2014), climate change will have a greater impact on livelihoods in the future, resulting in human suffering and risks. Climate fluctuation and variability are going to worsen with time and hence, correct adaptation and mitigation measures must be put in place to reduce the impacts. Several complementary measures are required to improve livelihoods at household levels in the research area. Local communities should create a variety of methods to combat the effects of climate change and variability. Intensification and application of modern agricultural practices and crop diversification; efficient and effective use and management of natural resources; use of chemical fertilizers to boost food production; enhancement of market policies; control of soil erosion; adopting behaviour change in response to climate change and variability; and building capacity and resilience are some of the measures that can be taken.

Another critical knowledge gap in transformation is how climate change's biophysical effects interact with socioeconomic systems and their important feedback loops across communities. While the current study in the region will provide some insight into these connections, time-series and temporal studies will be required to track how climatic disruptions affect the community and how individuals and communities respond. This type of analysis is necessary to comprehend essential thresholds as well as to assess policy levers that influence social resilience, which determines adaptation capability (Smit and Pilifosova, 2001).

Farmers' involvement, contributions, inventions, and creativity should be taken into account when creating transformation knowledge since they possess traditional technologies that must be combined with modern technology to effectively address the effects of climate change.

Collaboration with development partners can be advantageous in the future since they have the knowledge, resources, and technological advancements that can result in creative responses to a changing climate (NCCAP, 2018). The current study examines significant yearly and seasonal fluctuations in temperature and rainfall during the past thirty years, as well as trends (1986-2015). Fluctuations in altitude, cropping systems, and land use intensity can be used to explain the relevance of temperature and rainfall variations. Communities' opinions of enough rainfall may be in line with meteorological observations, such as late onset, mid-season droughts, and early termination. The results of this study are in agreement with a number of other comparable studies that have been carried out in various parts of the world, showing that temperature and rainfall patterns are changeable. Communities' opinions of enough rainfall may be in line with meteorological observations, such as late onset, mid-season droughts, and early termination. Changes inweather patterns are predicted to have a considerable impact on cropping systems and livestockproduction. It stands to reason that some places in the study area are more vulnerable to climatechange than others (Saarinen *et al.,* 2012).

Lack of funding directly affects adequate research to respond to climate vagaries that affect performance of cropping systems based on innovations. Availability of funds can help carry out research, establish institutions for training in climate change at local levels as well as create a rotating fund which can be borrowed by smallholder farmers for investment to boost agricultural production and agri-businesses (NCCAP, 2018).

The current research looks at important annual and seasonal rainfall and temperature changes, as well as trends, during the last thirty years (1986-2015). The significance in variations in temperatures and rainfall can be attributed to variations in altitude, cropping systems and land use intensity. Communities' perceptions of rainfall sufficiency may be consistent with observed meteorological data, such as late commencement, mid-season droughts, and early termination. Several additional similar studies conducted in different parts of the world agree with the findings of this study, indicating that temperature and rainfall patterns are variable. Communities' perceptions of rainfall sufficiency may be consistent with observed meteorological data, such as late commencement, mid-season droughts, and early termination. Several additional similar studies conducted in different parts of the world agree with the findings of this study, indicating that temperature and rainfall patterns are variable. Cropping systems and livestock output are anticipated to be significantly impacted by changes in weather

patterns. Naturally, some of the study area's regions are more vulnerable to climate change than others (Saarinen *et al.,* 2012).

The majority of agricultural production strategies should always put an emphasis on supply- side interventions like better seed varieties and the use of chemical fertilizers in order to increase productivity.

Going forward might be a better choice. Due to their high rates of poverty and the knowledge that the increasing output will ultimately lead to this, many people pay insufficient attention to the demand side. Increased farm production is likely to result in more excess that may be sold for the anticipated economic gains once people have satisfied their subsistence needs. A rise in productivity can be caused by better seed varieties, chemical fertilizers use and favourable weather (NCCAP, *2018)*.

CHAPTER THREE: STUDY AREA AND METHODS

3.1 Introduction

This chapter covers the study area's location, biophysical setting, socioeconomic context, and conceptual framework, as well as techniques and data synthesis. The chapter also contains data collection processes of FGDs, KIIs and household questionnaire surveys, desktop studies,fieldwork studies, data analysis techniques for rainfall and temperature data and overall data analysis.

3.2 Location of the study area

The study area lies approximately between latitudes 0º47'3N - 0º - 52'3N and longitudes 34° - 37'3E - 34º 43'E (Figures; 3.1 and 3.2) (ROK, 2009). The study area borders Mt. Elgon Forest to the north and to the west and extends from the upland to the lowland areas. To the south it borders *Kimilili* Sub–county and to the East it borders *Kaptama* Division. The study area spreads across twelve Sub–locations that include *Chemwesuis, Bugaa, Komtiong'*, Kapsokwony, *Kibuk, Kimobo, Nomorio, Kipyeto, Koshok, Saboncho, Sacha* and *Kamuneru* in Figure 3.2 (ROK 2009), climate change and variability, as well as the exponential growth of the human population, have all contributed to this. Climate change has a significant impact on people's livelihoods. Due to susceptibility to both climate change and climatic fluctuation vagaries, households are susceptible and at risk (Amwata *et al.,* 2015). As a result, planned adaption measures must be developed and improved in order to help manage the risks ofclimate change and variability. Adaptive capacity and resilience must be improved and built in order to reduce vulnerability, especially for the most vulnerable and impoverished socioeconomic groups. The study area is located on the fertile slopes which are directly affected by climate driven anthropogenic activities. Climatic change is already stressing the livelihoods of the poor in the region (FAO, 2013; World Bank, 2015).

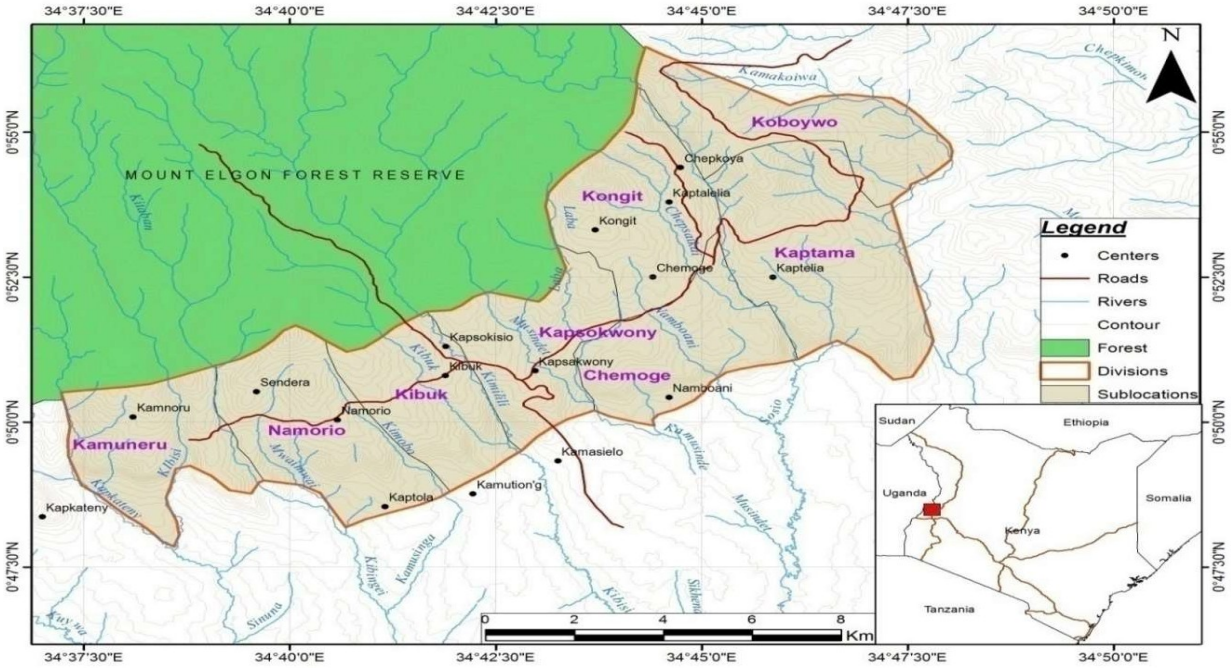
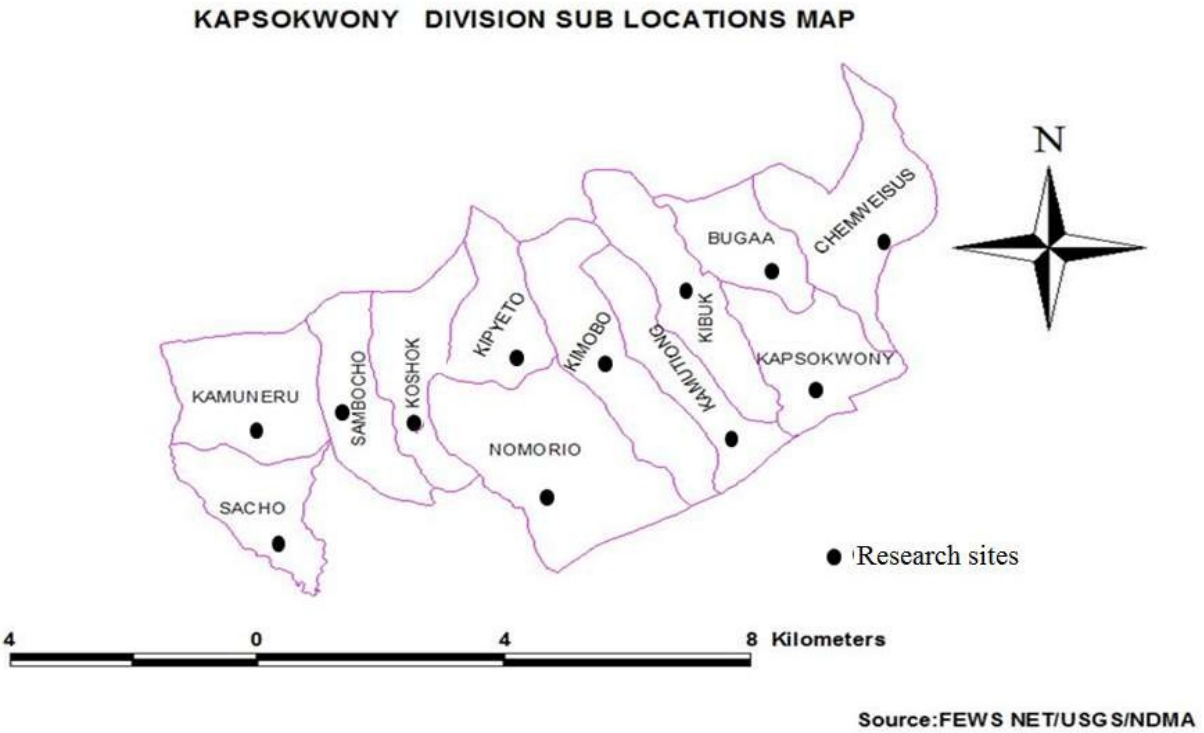


Plate 3.1: A photograph oh Mt. Elgon region, Kenya showing the study area between latitudes (Source: Survey of Kenya 2016)

Plate 3.2: A map of study area showing sub-locations research sites between latitudes



(0°47'3N - 0º52'3N and longitudes 34°37'3E - 34º 43'E) (Source: Survey of Kenya 2016)

3.3 Biophysical setting

The jutting volcanic rocks, which were generated millions of years ago by the process of volcanicity, are part of the region's key physical features (Wesche, 2002). Due to land evolution and the process of physical and chemical weathering, the landscapes and land structures of Mt. Elgon landforms are changing. Continuous fault movements and long-term effects of erosion have shaped the landscape into what it is today (Wesche, 2002). Mt. Elgon, like any other landscape, is exposed to the effects of climate change and many types of weathering. The principal conditions responsible for sculpting the landscape are the annual alternating wet and dry climate conditions. The majority of erosion occurs upstream, while deposition occurs downstream in the floodplain (Wesche, 2002).

3.3.1 Climate

Precipitation and temperature are two of the most important elements that influence lifestyles in the study area. The climate pattern of this area follows seasonally alternating moist (south-easterly) and dry (north-easterly) air currents. The wettest months are March to October, and the driest months are November to February (van Heist, 1994). According to annual rainfall records, the southern and western slopes receive more than 2,000 mm of precipitation, whereas the northern and eastern slopes receive only about 1,500 mm. In the recent days, rainfall has become increasingly unreliable and unpredictable. Overall, the region experiences a trimodal pattern of rainfall, with the wettest months being between April and October and the major dry season falling between November and February (van Heist, 1994). The southern and western slopes receive (about 2,000 mm per year), while the northern and eastern slopes receive (approximately 2,000 mm per year) (about 1,500mm. annually). The biggest amounts of rainfall fall on the slopes, while mild rain falls at high elevations (van Heist, 1994). The area's maximum yearly temperatures range from 27°C to 30°C, with lowest temperatures ranging from 16°C to 18°C (Wesche, 2002).

3.3.2 Vegetation

These vegetation zones of Mt. Elgon Ecosystem include: a) the lowland vegetation zone; b) the upland vegetation zone; c) the forested area vegetation zone; d) the bamboo vegetation zone; and e) the moorland and alpine vegetation zone (GoK, 2018). The forested area vegetation zoneis characterized by heavy anthropogenic activities including conversion to agricultural land, wood

fuel collection, illegal logging and expansion of human settlements (GoK, 2018). Deforestation is the removal of forest canopy on a wide scale before it is replaced. Deforestation also refers to the widespread removal of forest canopy before it is replaced by other land uses. Forest degradation differs from deforestation in that it results in forest quality deterioration (GoK, 2018). However, the two are intertwined, resulting in a slew of issues. Considerable loss of forest cover promotes soil erosion and destabilization of watersheds, culminating in landslides during heavy rains (Mugagga *et al.,* 2012). The livelihoods of between five hundred to 1 million people in the ecosystem who depend on the forest resources for food, shelter and fuel are at stake. The wanton destruction of the forest vegetation has changed the weather patterns in this region e.g. temperatures have increased and rains have become unreliable and unpredictable. Climate change will definitely increase risks and increase risks in numerous mountain places across the world where they were previously unknown (Kohler and Maselli, 2009).

3.3.3 Land uses and resources

Agriculture and livestock husbandry are the primary activities of the communities living in the study region. The main crops that are grown include maize, beans, potatoes, onions, tomatoes and vegetables though cash crops mainly coffee and tea. Although subsistence farming is the major economic activity, livestock rearing is practiced by almost all the households (GoK, 2018). Economic trees are also grown by most of the households for domestic use and social – economic income (GoK, 2014). Crop yield has been decreasing in recent years and a decline in livestock productivity due to un-characteristically changing weather patterns. Serious impacts have been observed in food security as a result of poor farming and livestock production though new maize varieties were recently introduced. Poor crop yield and a decline in pasture cover are symptoms of irregular rainfall, rising temperatures, loss of soil fertility, and wind erosion (GoK, 2014).

According to Appendix 7, each household has an average farm size of 4 acres, and the total area under food crops is 8,000 ha, compared to the entire area under cash crops, which is 20,000 ha (50 ha). Cattle (about 306,815), sheep (roughly 182,683), goats (approximately 48,402), and donkeys are among the livestock raised in the area (approximately 5,465). (GoK, 2018). The Victoria, Turkana, and Kyoga Lakes, as well as the Nile River, the longest river in the world, all have water catchment areas that include the research region. Although rivers and streams ramify and extend out of the mountainous terrain in all directions, their currentcarrying capacities are only about 17,779.5 animals per volume, according to information from the

Kapsokwony Fact Sheet (Appendix 7).

The research region is part of the water catchment area for the Victoria, Turkana, and Kyoga Lakes, as well as the Nile River, the world's longest river. Rivers and streams ramify and radiate out of the mountain terrain in all directions of the mountain though at the moment the volumes of these rivers carrying capacity is approximately (animals) 17,779.5. Fisheries production is a scant activity in the study area with only 11 fishermen are present and there are zero (0) fish farms. The type of fish found in rivers include: *Tilapia nilotica, Amphilius jacksoni* and *Pseudocranilaburrus mutlicolor.* Only a few people eat fish and this is why fish rearing is not common. The intensification of land use and a rise in human settlements may potentially lead to an abstraction of water resource in Mt. Elgon Rivers thereby reducing the water quality and also the water quantity (Sindani, 2013). The deterioration of these water parameters will obviously have serious effects on the ecological integrity and the ability of these rivers to support the human population, livestock and entire agricultural output. Government mechanisms in charge of enforcing environmental rules, including adaption technology, are underfunded, making it doubtful that they would be able to respond to the whims of climate change.

3.3.4 Physiography and drainage

Rivers in the study area are beginning to dwindle due to reduced annual rainfall and the changing global climate (van Heist 1994). The waters of these rivers flow on well-defined volcanic river beds. The rivers provide a vital source of good drinking water for millions of people and their domesticated animals, wild animals and plants that inhabit the area. Therefore, the mountain is a vital socio-economic functioning of the area (van, Heist 1994). Vegetation allows excess rain water to soak into the soil from where water is gradually released. This minimizes both downstream flooding and drought condition. Downstream small streams coalesce to form big rivers like rivers *Nzoia* and *Lwakhakha* (van, Heist 1994). The water of the rivers is brown in colour because they go through settlement and cultivated and in the process, they receive a lot of silt and sediments and hence, the brown colour (van, Heist 1994).

3.3.5 Water resources

The number of rivers and wet lands are five (5) namely: *Chemwesus, Masindet, Kibisi, Sendera* and *Kamuneru* in accordance with (Appendix 7) details of Kapsokwony Division fact sheet. Rivers and streams ramify and radiate out of the mountain terrain in all directions and they flow

on volcanic river beds from the upland to the lowland reaches (GoK, 2018). The study area's wetlands and springs provide water for both humans and animals. For drinking and agricultural purposes, many people in the environment rely largely on groundwater. Lowstream-flows put human and environmental systems under stress since there is less water available and water temperatures are higher (GoK, 2018). The numbers of rivers are five (5) namely: *Chemwesus, Masindet, Kibisi, Sendera* and *Kamuneru* in accordance with (Appendix 7) details of Kapsokwony Division fact sheet. Increased societal water demands in areas that already rely on groundwater will put a strain on this resource, which is frequently depletedfaster than it can be replenished (GoK, 2018) Reduced availability of surface water for agricultural production could result in deepened poverty of area residents. (GoK, 2018). Finally, a rapidly growing population is putting a pressure on limited water resources, resulting in increased storm frequency and/or intensity, as well as lengthy droughts (GoK, 2018).

Streams in Mt. Elgon Ecosystem tend to exhibit radial drainage patterns. The Mount Elgon habitat serves as a water catchment area for Lakes Victoria, Turkana, and Kyoga, as well as the Nile River, the world's longest river (GoK, 2018). Rivers and streams ramify and radiate out of the mountain terrain in all directions of the mountain though at the moment their volumes are beginning to dwindle due reduced annual rainfall and changing global climate. These rivers and streams flow on well-defined volcanic river beds (GoK, 2018). Therefore, the mountain is vital to social economic functioning of the area (GoK, 2013). In the emerging urban centers, such as Kapsokwony town, there are 438 houses having access to piped water. Those who have access to portable war, on the other hand, are about (1,340). With a total of one Water Resource User Association, the average distance to the nearest water point is (0.5 km) (WRUA). In 62 percent of houses, there are latrines (GoK, 2013).

3.3.5 Biophysical vulnerabilities

Human encroachment and the degenerating climatic conditions are causes to the deterioration of tourism, agricultural activities in the region. Healthy ecosystems and their services, according to Travers *et al.,* (2012), provide opportunities for long-term economic prosperity while also providing protection against the negative effects of climate change, and ecosystem degradation, on the other hand, increases climate change vulnerability for both the communities that live in these ecosystems and the ecosystems themselves. The important sectors are threat due to indiscriminate decimation and degradation of the ecosystem (GoK, 2018). Illegal logging,

charcoal burning, over-grazing of animals and human encroachment coupled with climate change are the activities that have resulted in the decimation and degradation of the natural resources (GoK, 2018). Increased fluctuation in water flow, resulting in either too much or too little water, will make mountain livelihoods more vulnerable (Kaltenborn *et al.,* 2010). For instance, the planting of eucalyptus along rivers and near swamps has been cited as the cause of reduced water levels in rivers and streams. Farming on river banks is another big threatto the ecosystem because it has resulted in sedimentation, siltation and the change in course of some of these rivers (GoK, 2018). In response to such vulnerabilities, Kenya's government recommends that actions to counteract climate change consequences be implemented in order to protect livelihoods (GoK, 2018).

3.3.6 Socio-economic setting

Climate change in combination with natural resource over-use, exponential population growth, poor farming systems, ecosystem degradation and lack of informed knowledge will culminate into many socio-economic stresses to agricultural smallholder farmers in the study area. Agriculture is the region's principal economic activity, with households growing commercial crops such as onions, tomatoes, and potatoes (NCCAP, 2018). In addition, they carry out livestock rearing and small agro-businesses to generate income ((NCCAP, 2018). Climate change is the biggest threat to socio-economic sustainability to agricultural smallholder families living in the study area. Food production and agricultural revenue are anticipated to drop in the future as climate change has an influence on livelihoods. In addition, they carry out livestock rearing and small agro-businesses to generate income ((NCCAP, 2018).

Most of the population in the study area lives on the fertile slopes on which they depend upon for food production and subsistence farming as well as livestock rearing. Those who live adjacent to the forested ecosystem have access to forest natural resources to support their livelihoods. Reduced competition can be created purposefully (forest clearings, grazed land, etc.) or naturally (forest clearings, grazed land, etc.) (forest gaps, unstable soils, unfavourable microclimates etc.). Flash floods and flooding are projected to become more common in Mount Elgon as a result of high land-use pressures, such as deforestation and extensive grazing, paired with excessive rainfall. Increased fluctuation in water flow, resulting in either too much or too little water, will make mountain livelihoods more vulnerable (Kaltenborn *et al.,* 2010).

Climate change and disaster risk reduction are inextricably intertwined. Many mountain regions

have become more disaster-prone in recent decades, according to scientific research, and are more frequently damaged than other ecosystems, earthquakes, volcanic eruptions, dam bursts, glacial lake outbursts, avalanches, and landslides are all examples of catastrophic natural phenomena (Kohler and Maselli, 2009). Deforestation and farming have resulted in significant loss of forests and forest cover on Mount Elgon, notably on the steep concave slopesof Uganda's Mt. Elgon National Park. During rainstorm events, these alterations have caused a succession of shallow and deep landslides in the area (Mugagga *et al.,* 2012), resulting in the loss of human life, livestock, and other asset. Certainly, the expanding population atop the mountain, as well as the resulting expansion of towns and infrastructure, increases the risk of landslides, especially when combined with climate change-related increases in heavy rainfall. Because climate change and related hazards are now clearly linked to issues like food security, shelter, and migration within the region, it is critical to manage catastrophes within a framework that combines climate change adaptation and disaster risk reduction (McBean and Rodgers, 2010).

3.3.7 Political and administrative context

Mt. Elgon District includes the Kapsokwony Division, which is part of the research area. Mt. Elgon is a trans-boundary environment shared by Kenya and Uganda. The Mt. Elgon Ecosystem is mostly found in Bungoma and Trans-Nzoia Counties, however the study area isin the former. Administratively, the area of study is found in Kapsokwony Division of Mt. Elgon District. The study area is located in Mt. Elgon constituency which borders *Sirisia* and *Kimilili* Constituencies (GoK, 2014). Kapsokwony Division is made of three locations namely: *Kapsokwony, Elgon* and *Nomorio* Locations. Most of the population is composed of the youth who face the future with a lot of uncertainty. Education opportunities are equally available for both the boys and girls but the latter likely drop out of school especially after undergoing genitalmutilation they get married. (GoK, 2014). Although a majority youth have had some education, employment is a big problem and this way life is very hard for them. Income generating activities are rare and hard to come by. In recent years, the study area has been plagued by poor rains and increased droughts, offering a challenge to farmers and restricting agricultural options for communities (GoK, 2014). Organic farming practices are a part of the future of agricultural production because there is no one methodology or technology that can make agriculture and food systems more sustainable. Impacts of climate change are projectedto increase migration of region populations to urban areas, particularly among the youth who aspire to a better quality of life. Negative climate change

consequences are particularly damaging to the region's potential economic sectors, threatening rural livelihoods and undermining economic development benefits (GoK, 2014).

3.3.8 Economic setting

The main economic activities in the region are the sale of crop products that include maize, beans, Irish potatoes and onions as well as livestock. However, crop and livestock production face a bleak future because of exponential human population that has led to the sub-division of available land into small plots (GoK, 2014). Prolonged droughts, shrinking of pastureland and rising livestock diseases could mark a significant drop in the economy of livestock production in the region. The smallholder farmers in the study area also plant economic trees which they sale to supplement to earn some income. To balance climate change impacts in the study area, a paradigm shift in agricultural and livestock production is required. This is because agriculture and livestock production are a prerequisite in the sustenance of livelihoods in the region.

Because they know less about elements that increase and promote resilience, impoverished people in the research region are expected to be more sensitive to the consequences of climate change (Leichenko and Silva, 2014). There is a need for more research into the possible effects of climate change on economic growth and poverty traps, as well as alternatives for coordinating adaptation initiatives with poverty reduction (Leichenko and Silva, 2014). The socio-economic potential of the region can be unlocked by enhancing the literacy level of the area residents. This can be achieved by allowing the youth to access technical vocational training opportunities and opening new technical institutions in the region (GoK, 2014).

3.3.9 Social setting

Though Mt. Elgon district is inhabited by three tribes namely the *Sabaot, Bukusu* and the *Iteso*, the main occupants of the study area are mainly the *Sabaots.* The youths out-number the middle and old generations forming up to approximately three quarters of the total population (GoK, 2014). Learning institutions are on the upward trend though boy schools out number girl schools though literacy levels are low. The rate of school dropouts is high and this can be attributed to high levels of poverty and traditional believes of area especially for those who do not value education (GoK, 2014). Women, the elderly, people with disabilities, children, youth, and members of the marginalized are among the most vulnerable in society, as they lack access to information and resources and are unable to participate in inclusive climate change action. These populations are subjected to disproportionate climatic impacts as a result of inequalities and inequality. Because of rising temperatures and humid conditions, climate change is known to promote an increase in the infection of most aquatic diseases (GoK, 2014).

Waterborne diseases are commonly associated with poor water quality with attacks commonly experienced during the rainfall periods (Sindani, 2013). All of this leads to weak early warning systems for epidemics and a slow, ineffective response to outbreaks. Inadequate disaster management and preparedness processes in the region exacerbate this situation, limiting the region's ability to deal with disasters and disease outbreaks (KHDS, 2011). Changing rainfall patterns and warming are expected to make meeting the requisite quality health requirements more difficult improve livelihoods in the study area.

Human health has been affected adversely with malaria, cholera, typhoid fever, dysentery, and diarrhoea are climate-sensitive diseases, as are waterborne infections like malaria, cholera, typhoid fever, dysentery, and diarrhoea. Food, increased heat stress, poor air quality, and extreme weather events are all negative health effects of climate change (KDHS, 2014). Allthis is as a result of insufficient early warning systems for epidemic occurrences untimely response to outbreaks. This situation has been compounded by inadequate crisis management and preparedness procedures exist in the region, limiting the region's ability to respond to disease epidemics (KDHS, 2014). Despite a human population of over 100,000 people, the region has only one (1) district hospital, one (1) public and four (4) private dispensaries. Undera changing climate, better health regulatory mechanisms should be put in place to manage outbreaks of diseases to stop loss of lives.

3.3.11 Regulatory framework

To protect livelihoods and maintain socio-economic growth in the studied area, the government has set in place rules, regulations, policies, or decrees that govern the flow of resources and services. There are coercive and contractual regulatory systems that exist legally at all levels, including municipal and national levels, to control services and acts. For example, the department of crop production has established laws that smallholder farmers can utilize to determine the kinds of chemical fertilizers and seeds to be used in the area. The departments also enforce procedures to maintain riparian habitats along rivers and how to control soil erosion, particularly along slopes (GoK, 2013). In order to boost output and reduce food insecurity in the area, the department of livestock production manages livestock diseases and pests. In order to report and control animal movement, pests and diseases, zoonosis, artificial insemination, and animal marketing, the department performs regulatory service role surveillance (GoK, 2013).

This study concentrated on national and local government operations, regulations, and policies. By passing the Climate Change Act, the National Government has already demonstrated its dedication to battling the impacts of climate change on livelihoods (Number 11 of 2016). The National Climate Change Adaptation Plan (NCCAP), which must be created in accordance with the Act, will guide the mainstreaming of adaptation and mitigation measures into the sector functions of the National and County Governments. By creating institutions and policies to support low-carbon, climate-resilient development, NCCAP 2018, which runs from 2018 to 2022, aims to assist Kenya in achieving its development goals. Based on a build Action Plan (2013–2017) that sought to create a framework for Kenya to fulfill its Nationally Determined Contribution (NDC) to the Paris Agreement of the United Nations Framework Conventions on Climate Change (UNFCCC). The NCCAP 2018 provides guidance to national and county governments, business, civil society, and other actors in their efforts to combat climate change. It is made up of Volumes I, II, and III as well as the Adaptation Technical Analysis Report (ATAR) and Mitigation Technical Analysis Report (MTAR).

In accordance to appendix 7, the average farm size per household is 4 acres, and the total acreage under food crop is (8,000 ha) while the total acreage under cash crop is (50 ha). The livestock reared in the region include cattle numbering (approximately 306,815); sheep (approximately 182,683); goats (approximately 48,402) and donkeys (approximately 5,465). The total land carrying capacity is approximately (animals) 17,779.5. Fisheries production is a scant activity

with only eleven (11) fishermen present and zero (0) fish farms (GoK, 2018). The type of fish found in some of the rivers include: *Tilapia nilotica, Amphilus jacksoni, Pseudocranilabarrus multicolour*. The reason as to why very people engage in this livelihood activity is that only a few people eat fish (GoK, 2018).

3.3.12 Socio-economic vulnerabilities

Natural resource extraction in the forested Mt. Elgon Ecosystem, Kenya poses significant risks to the environment and human beings, contributing to climate change, and increased socio-economic vulnerabilities. However, the ecosystem is faced with enormous drivers that include climate change, deforestation and various anthropogenic activities that render it vulnerable (UNDP, 2012). The ecosystem is projected to undergo a wide range of repercussions as a result of climate change and deforestation on the natural environment, natural resources, and socio-economic vulnerability. Because there is a scarcity of data on the influence of climate change on livelihoods, little is known about the socio-economic vulnerabilities in the research area. Changes in precipitation patterns and rising temperatures are likely to cause significant changes in water supply, agriculture, grazing land, and natural hazards, all of which will have an influence on human well-being. Similarly, decisions must be taken about adaptation measures that can help to mitigate or avoid some of climate change's negative consequences. There's stilla lot to learn about the efficiency of different sorts of adaptation responses, as well as how they'll interact with one another and mitigation measures. As society learns by doing, responses to the climate change dilemma will very certainly vary over time.

3.4 Conceptual framework

The (Fig. 3.3) below shows a comprehensive and holistic approach to understanding the vulnerability of the communities to climate change and variability in the study area.

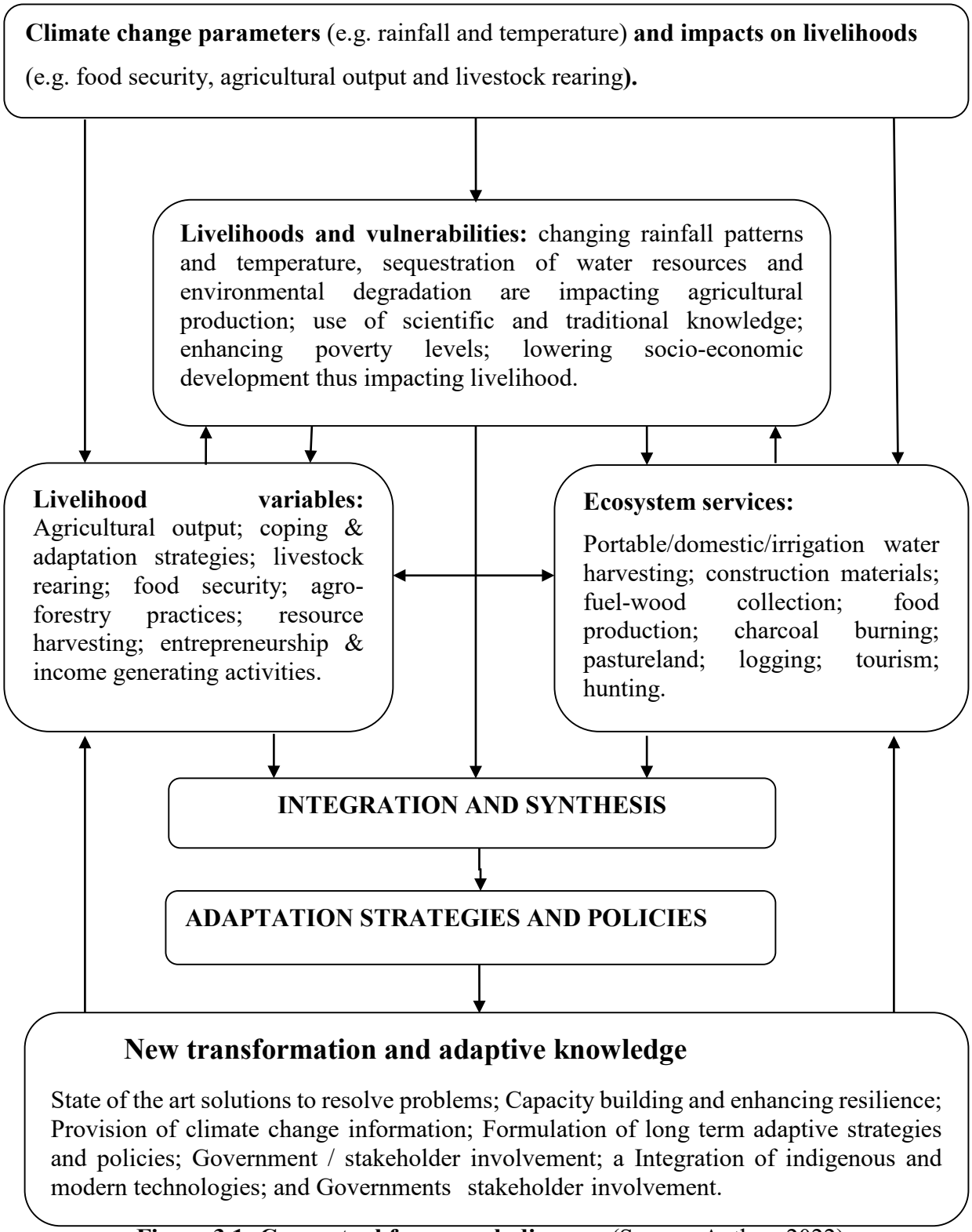


Figure 3.1: Conceptual framework diagram (Source: Author, 2022)

Climate change and livelihood variables have a strong association, according to the conceptual framework (Fig. 3.3). The degree to which ecosystems, food security, and sustainable development are threatened by climate change is determined by both climate change exposure and people's ability to adapt to and respond to climate change issues (GoK, 2018). Although climate change is a direct cause of food insecurity (GoK, 2018), it is important to rememberthat climate change is not the sole determinant of yields or the only physical environment component that influences food security (Parry *et al.,* 2004). Reduced climate change consequences on agriculture and livestock output should be a top focus for policymakers.

Although climate change is a direct cause of food insecurity (GoK, 2018), it is important to remember that climate change is not the sole determinant of yields or the only physical environment component that influences food security (Parry *et al.,* 2004). In order to attain food security, the government, all partners, and region inhabitants should make reducing climate change impacts on agricultural and livestock output a top priority. This is partly due to the fact that agriculture is one of the most vulnerable industries to the effects of climate change on livelihoods, as it is naturally prone to harsh climate conditions (according to GoK, 2018). As a result, conservation agricultural practices will always be able to buffer the loss of soil moisture while still providing favorable food security effects.

The integration and synthesis of multiple sources of knowledge from various stakeholders are desirable in order to address the numerous concerns that climate change and variability pose to family livelihood systems. Instead of being considered as a static state of a system, the resilience pathway is understood as a process. To lessen their susceptibility, households and communities should employ their adaptive capability and choose a resilient pathway to handle pressures they are exposed to incrementally. This is due to the fact that resilient communities have access to knowledge and can engage in well-informed decision-making that affects their lives. The goal of this research is to better understand the effects of climate change on rural livelihoods in the study area. It also leads to a more comprehensive knowledge of how vulnerable communities are to climate change and variability. The research combines community-specific adaptation and coping strategies with long-term and short-term adaptive measures to maintain development and improve livelihoods.

As a result, in the face of growing climate change and variability threats to livelihoods, it is critical to support and strengthen existing adaptive capacity while integrating scientific and

traditional technologies, gaining access to new transformation knowledge, and developing innovative ideas and approaches to respond to changing scenarios. This framework will enable problem solving by transforming attitudes and human behaviour, creating adaptive ability and enhancing resilience, as well as providing climate change information and natural resource conservation. It aided in the providing of scientific evidence in order to build long-term strategies and policies to sustain socio-economic growth and improve the livelihoods of the region's residents. To prevent climate change and improve livelihoods, action knowledge was to be formulated from several disciplines.

3.5 Research design

The purpose of this study was to investigate the effects of climate change and variability on livelihoods in Kenya's Kapsokwony Division, Mt. Elgon Sub-county. During data gathering, a combination of qualitative (focus group talks, informant and in-depth interviews) and quantitative (questionnaire survey) methodologies were used. This study was a collaborative effort to increase resilience and adaptive capacity in the face of climate change. Several data collection methods were employed climate information was restricted to rainfall and temperature trends from 1986 – 2015. At the end of the study, adaptive strategies and policies were generated to improve livelihoods and sustain socio-economic development. The livelihood aspects which were investigated included crop faming, livestock production, land use, food security, coping with weather related events, impacts of slow onset of climate change and agribusinesses. As part of the adaptation strategies, expected responses were to develop adaptive capacity and build resilience of the people living in the region, while also maintaining ecosystem production as part of the adaptation strategies, particularly for the most vulnerable groups (Tompkins and Adger, 2004; Reid *et al.,* 2008; and WRI, 2008).

The household survey questionnaire which had four sections generated mostly quantitative and partially qualitative data. The questionnaire's first component covered general, socioeconomic, and demographic factors, followed by two sections on dealing with extreme weather occurrences and adaptation. The following section mirrored gradual environmental changes in order to analyze the impact of climate stressors on households, as well as their techniques for dealing with and adapting to the effects of extreme weather-related occurrences. The questionnaire's final portion included open-ended questions to probe respondents' perceptions of vulnerability and policy alternatives for mitigating climate threats. It takes between 20 and

30 minutes to finish each questionnaire interview. Qualitative data was gathered through focus groups and KII interviews. This data was used to supplement the data from the household survey (questionnaires). Three focus groups were held to get community feedback on the effects of climate change on livelihoods. Interaction among respondents sparked new ideas and perceptions about climate risks, such as the frequency and severity of climate impacts changing over time, impacts, responses, constraints (factors impeding effective coping and adaptation), and policy (what governments and organizations could/should do).

During KIIs and FGDs, those interviewed were people with expert knowledge and traditional knowledge mainly aged between 30 – 60 years. During the HH questionnaire survey, the respondents were identified from households across twelve (12) sub-locations that form Kapsokwony Division. The sample was proportionately allocated for each of the sub-locations based on the number of households within each sub-jurisdiction. The householdswere chosen at random, starting at the most central section of each sub-location, as directed by the village elder. The first household was randomly picked from this point, and subsequently every fifth household was systematically selected in a clockwise direction until the required numbers were achieved per sub-location. The targets of the structured survey questionnaires were male heads of households and in their absence their spouses could be interviewed instead. In the absence of either of the spouses the next household would be targeted for the collectionof the same information. The study took into account the respondents' perceptions and experiences of long-term trends and variability in rainfall and temperature parameters.

Data analysis was carried out by use of statistical, descriptive and narrative techniques. Rainfall trend analysis was done by use of Student's t-test while the F-test was used to analyse annual rainfall variability while linear regression was used to confirm and visualize the results. Trend analysis demonstrated the general movement of the rainfall patterns and examined changes in the rainfall quantities. Famer's rainfall and temperature perceptions were analysed by use of thematic and descriptive statistics. The specific nature of the study was trans-disciplinary research where the experts from the academia (non-experiential) talked to traditional society (experiential) and the society talked back to experts to share the perceptions on impacts of climate change on livelihoods.

3.5.1 Data collection methods

This section discusses the methods utilized to collect both primary and secondary data for the study's objectives. A household survey, focused group discussions, in-depth interviews, and key informant interviews were utilized to gather primary data. Secondary data was also gathered from the existing literature, which included unpublished and published reports from relevant ministry departments, peer-reviewed publications, and on-line sites. To validate the variations in rainfall and surface temperatures, meteorological data from the nearest reporting weather station, Kitale Meteorological Station (KMS), was gathered, recorded, and analysed. The data was coded and analysed with the use of the Statistical Package for Social Scientists (SPSS), descriptive statistics, and regression analysis.

3.5.2 Desktop studies

Mean rainfall and mean surface air temperatures ($T_{\text{Max.}}$ and $T_{\text{Min.}}$) data were obtained from Kitale Meteorological Station (KMS) covering the period 1986 to 2015. Interviews with heads of relevant government departments The specific government departments include the Education Officer, Head of Biko Kapkorret Radio Station, Head of Nzoia Water Company, Ddistrict Officer and District Livestock Officer and Non-Governmental Organizations (NGOs) together with interviews carried out during FGDs, KIIs were the major sources of the required information. The administration of survey household questionnaires to heads of households provided information to complement information from other sources. To supplement the information from the climatic data and review the implications of climate change on livelihoods in the research area, additional material was acquired from published journals, GoK reports, the internet, and international agreements.

3.5.3 Fieldwork studies

a) Overview

Primary climate data on climate change was collected through interviews and dialogue during KIIs and FGDs. This information was complemented with data collected during the administration of the household questionnaires to heads of households and analysed for trends and variability. During Focus Group Discussions (FGDs), some of the sample questions asked to participants included: a) What is your perspective of historical climatic patterns over the last

30 years? b) Do you believe that changes in weather patterns have had any impact on the region's livelihoods? c) What are the implications of the changes in weather patterns on livelihoods during the period? (see Appendix 08).

The Household (HH) surveys were chosen at random, starting in the center of each sub- location. The study's respondents were drawn from households in 12 sub-locations of theKapsokwony Division, namely: *Kamuneru, Sacho, Saboncho, Koshok, Kipyeto, Kapsokwony, Kibuk, Bugaa, Chemwesuis, Kamtiong', Kimobo and Nomorio.* The first household was chosen from the center of the Sub-location's and every fifth household after that was methodically chosen in a clockwise pattern until the required number of households (32) was reached per Sub-location. Household heads (aged between 45-70 years) were interviewed and where they were absent, dead or divorced their spouses were interviewed instead. The sample size consisted of a total of 398 respondents who were heads of households selected from the target population of approximately 90,130 people. To obtain an appropriate size of the stratum, a formula by Yamane (1967) was used.

The entire population size of the research region was divided by the population size of each sub-location, which was then multiplied by the total sample size n. According to the 2009 Population Census (PC), the overall population of the study region was well between 90,130 persons, therefore the number of houses to which the survey household questionnaires (sample size) were administered was 398.

Yamane (1967) gives a formula for calculating sample sizes that is easier to understand. At a 95% confidence level, the formula was used to calculate sample sizes, and P = (0.5). The range in which the true value of the population is estimated is known as the level of precision, often known as the sampling error. The percentage points (5%) are always used to indicate this range. The following equation was used to get the total sample size in the study area:

$$n = \frac{N}{\{1 + (Ne)^2\}} \quad \text{.....[Equation 3.1]}$$

Where,

N = the population size (Area of Study based on 2009 Population Census (90,130)

e = the margin error (0.05)

n = 90,130 / 1 + 90,130 (0.05^2); therefore n = 398

The household questionnaire survey (Appendix 01) generated mostly quantitative data although it also contained open livelihood questionnaire in section (2.1) to provide qualitative information. The questionnaire was divided into four areas: socio - economic, demographic, and two sections on coping with extreme weather events and adaptation to the effects of climate stressors on households, as well as techniques for dealing with extreme weather-related occurrences. The questionnaire's final portion included open-ended questions to probe respondents' perceptions of vulnerability and policy choices for mitigating climate change and variable threats.

To gather data through the administration survey household questionnaires, six (6) field assistants were hired locally from the study area's communities. The training process lasted two (2) days and was piloted prior to the start of the interviews. The goal of the training was to eliminate pre- perceived errors and bias during the delivery of household questionnaires while also familiarizing the field assistants with the research's specific aims. Necessary corrections and modification on the household questionnaires were also carried out during the pilot test and thereafter the actual data collection was carried out. The distribution of questionnaires to heads of households was done in order to increase community participation in the research process as co-producers of knowledge. A pilot test of the data gathering tools was conducted prior to the start of the actual data collection. This was done to assess the research instruments' applicability and dependability, as well as the field assistants' capacity to administer the research tools.

b) Focus Group Discussions

Focus Group Discussions were held with persons from various backgrounds, including experience, gender, age, education, and wealth. Those who were considered for the discussions were men and women with a lot of experience in related farming activities, aged above 45 years with at least middle level education and both from the poor and well-off backgrounds. The participants were mainly smallholder farmers from the rural areas who practice subsistence farming, livestock keeping as well as business folks. The participants were drawn from the public representing all the sub-locations and private organizations. Local authorities, such as village elders, assistant chiefs, and extension officers, assisted in the selection of those who participated in the dialogue. The first condition was that they had lived in the area for more than 30 years and had knowledge of the research sites' history and memories, particularly the evolution of climate variability and livelihood modification. FGDs encourage participants to interact with one

another, resulting in verbally articulated thoughts and opinions on the study issues.

The three FGDs were held in Kapsokwony Multipurpose Development Centre (KMDC) on the 24th, to 25th June 2016 respectively. These FGDs, similar to the household survey, addressed issues that cut across all the specific objectives. The questions addressed during FGDs were as follows: i) whether farmers in the study area had perceived any changes in weather patterns; ii) whether smallholder farmers thought changes in weather patterns had affected livelihoods or not; iii) whether implications in the weather patterns had increased or decreased crop production and livestock rearing from the years (2006-2015); iv) what residents have done to adapt to changing weather patterns; and v) (Appendix 08) What strategies could be advocated to assist mitigate the effects of climate change in the study area?

The focus groups were convened to supplement the findings of the home interviews while also probing the issues faced by the most disadvantaged households in communities and identifying potential coping adaptive solutions. The participants' interactions sparked new ideas and views regarding climate hazards, such as the frequency and intensity of climate impacts changing over time.

c) Key Informant Interviews

During KIIs, data on how climate influences livelihoods in the research region was gathered that was important to this goal (Appendices 09 and 10). Interviews with smallholder farmers and heads of government ministries took place around this time. KIIs were also utilized to gather information from people with specific knowledge and experience on how climate change affects livelihoods in the region, as well as to corroborate data from focus groups and household survey questionnaires. District Livestock Officer, Medical Officer in Charge of the District Hospital, District Livestock Officer, District Education Officer, Head of Kenya Forest Service, a representative from the Meteorological Department, and a journalist from local radio station Biko Kapkoret were among those interviewed (FM). The key informant interviewees representing the local community included an experienced traditional weather expert, a retired teacher who is a farmer, two (2) youths, and two (2) women. Six (6) Key In-formant Interviews with smallholder farmers were conducted as from 8th to 27th January 2016 whereas six key In-depth Interviews with heads of government departments were conducted as from 7th to 25th February 2016. The KIIs were conducted face to face with those from across the different sub-

locations and those who head selected departments with knowledge of changes in the environmental weather patterns.

During the KIIs, the following were the primary topics discussed: i) sources of livelihood; ii) perspectives on rainfall and temperature parameters in the study area; iii) whether there are any techniques for predicting rainfall; iv) how frequently drought occurs in the region; v) whether changes in weather patterns have impacted the region's agriculture and food systems; vi) what coping techniques do smallholder farmers use to adapt to climate change's effects.

vii) whether poverty levels were increasing or decreasing; viii) whether farmers require assistance to adapt to climate change vagaries or not; ix) what strategies would be useful to mitigate impacts of climate change; and x) whether the government should move in to help the most adapt to climate change impacts. The villagers' perceptions of rainfall and temperature were also captured during KIIs.

3.5.4 Data analysis

a) Overview

Student's t-test was used to analyse trends, while F-test was utilized to examine yearly rainfall variability, and linear regression was employed to determine trend significance. Descriptive statistics were used to assess farmers' rainfall data perceptions. Means, maximum and minimum temperature values, climate trend graphs and charts were among the statistical and graphical data analyses performed on the climate data. The size, direction, and significance of annual and seasonal rainfall trends were determined using linear regression, while the combined data for rainfall and temperatures was analysed using the F-test. The general patterns of was then drawn to make predictions about the future rainfall.

This study assessed trends and variability in total seasonal and yearly rainfall genera ted from monthly rainfall readings to discover local rainfall variability in the study area. Inspection of each time series for discontinuities was done first, and then the Student's t-test was used to test for homogeneity (von Storch and Zwiers, 1999). The goal of the trend analysis was to reveal the overall movement of the rainfall patterns while also looking at any changes in rainfall levels. Respondents were asked two questions to better understand their opinions of rainfall variability and trends: a) What are your perceptions of historical climatic patterns over the last 30 years? b) What are the effects of changing weather patterns on people's livelihoods throughout time?

(Appendix 10). The use of statistical and graphical approaches was then used to analyze changes in rainfall patterns.

The completeness and consistency of data is important in any research works for determination of homogeneity over the study area. Single mass curve method was used to examine whether the historical climate data are samples from the same statistical distribution by checking the drifts in the data set which have taken place in the region.

The F-test was used to compute rainfall variability in order to compare the equality of the mean rainfall for each year and characterize the convention events of the rain in the study area. The outcome of this test would give an overview of climate fluctuations and the degree.

b) Precipitation trend analysis

Trend analysis was done by use of graphs depicting time series which were drawn and analysed in excel. Variability and time series trend analysis of long time and short term of rainfall during the season of MAM and OND respectively were drawn to depict the trends during these seasons. The significance of trends for rainfall and temperature was done using Microsoft Excelwhile the linear regression was used to confirm and visualize the results. Microsoft Excel is preferred because it has in-built tools, thus the ability to analyse climate data in form of graphs, charts and tables. Microsoft Excel enables users to format, irganize and calculate data in a spread sheet. This makes information easier when data is added or changed. At a 95% level of confidence, simple linear regression was employed to examine the significance of the dependent variable's trends.

The equation of a linear regression line is given as:

$y = bx + a$ ..... …..[Equation 3.2]

Where,

y = total annual rainfall;

a = the intercept;

b = the slope of the line indicating the rate of change over the years; and

x = time measure in years.

The link between the dependent and independent variables was modeled using linear regression

modeling which resulted in positive and negative slope values showing increasing and declining trends, respectively. The data was drawn and analysed via Microsoft Excel software, which provided two benefits. For example, Excel is not a non-parametric test because it is based on assumptions about the distribution of thr population that doesn't necessitate normally distributed data. Second, due to inhomogeneous time series, the test has a low sensitivity to abrupt breaks. The null hypothesis (H_0) in this test implies that there is no trend and that the data is independent and regularly distributed. This is compared to thealternative hypothesis (Ha), which states that:

The difference between the means in the data sets was then examined using the student t-test. The data was initially inspected for discontinuities before being tested for hypothesis about the mean using the Student's t-test (von Storch and Zwiers, 1999). It was confirmed to be normal and independent.

The student t-test is given by the following formulae:

$t = \frac{\bar{x}_1 - \bar{x}_2}{\sigma_d^2}$ .....[Equation 3.3]

Where,

σ_d= is the difference in variance given by:

$\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}$ ....[Equation 3.4]

Where,

$\bar{x}_1$ and $\bar{x}_2$ = are the means of the two samples;

n_1 and n_2 = are sample sizes; and

$\sigma 1 \; and \; \sigma 2$ = are variances.

The computed t was checked against the tabulated t and null hypothesis accepted (rejected) if the computed t is smaller (larger) than the tabulated t.

Pearson's correlation analysis was used to examine the association between rainfall and temperature over the study period. It is computed using the following formula below:

$$r_{xy} = \frac{\frac{1}{n}\sum_{i=1}^{n}\left[\left(x_i - \bar{x}\right)\left(y_i - \bar{y}\right)\right]}{\left[\frac{1}{n}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2 . \frac{1}{n}\sum_{i=1}^{n}\left(y_i - \bar{y}\right)^2\right]^{\frac{1}{2}}} \quad \text{..... [Equation 3.5]}$$

Where,

r_{xy}= the correlation coefficient,

$\boldsymbol{x}$ = rainfall, and

y = temperature.

The significance of the computed correlation coefficients was then analyzed using the student t-test given by equation 6 below:

$$t = r\sqrt{\frac{N-2}{1-r^2}} \quad \text{.....[Equation 3.6]}$$

Where,

t = the computed value of t,

r = the correlation coefficient between the variables, and

N = the number of years used.

These values were compared with the tabulated values of t and a decision was made. When the computed value t is larger than the tabulated value, the correlation is significant and vice versa.

(c) Rainfall data analysis

Monthly observations of rainfall and temperatures for the present research were acquired from Kitale Meteorological Station (KMS). The climate data was thereafter subjected to homogeneity test to verify for its consistency and to whether it was good for use in the studyas well as to whether it was derived from the same population distribution. The cumulative totals of rainfall and temperature were plotted in excel (graphical analysis) against the years to check for data (in) consistency (Figures. 4.1 and 4.2).

The study period's dry and wet years were determined using the Standardized Anomaly Index (SAI). SAI was created to calculate precipitation deficits over a variety of time scales (McKee *et al.,* 1993). The SAI is computed by multiplying the difference between normalized seasonal precipitation and its long-term seasonal mean by standard deviation (Koudahe *et al.,* 2017).

$$Z = \frac{x-\bar{x}}{\sigma} \quad \text{.....[Equation 3.7]}$$

Where,

Z = the standard deviation in rainfall;

x = the total yearly rainfall for a given year;

$\bar{x}$ = the annual rainfall average; and

σ = the rainfall yearly standard deviation over the observation period.

The year-to-year variability over the study area of annual and seasonal rainfall was done by

use the F-test. The samples from which the sample populations are drawn are normally distributed and should be independent of each other. The F-test compares two population variances which always are equal to 1. You can reject the null hypothesis if the estimated F-test is greater than the F statistic. However, the F statistic is only one measure of significance in an F-test. The F-test was computed by comparing the equality of the mean rainfall from each year to characterize the convention events. The whole data set of the rainfall from 1986 - 2015 was divided into two equal sets and the means computed. From the means obtained the variances of the data sets were computed. The null hypothesis (H0) and the alternative hypothesis (H_a) were stated. The F-test value was calculated as follows:

$F = (SSE_1 - SSE_2/m/SSE_2/n\text{-}k$ ..... …[Equation 3.8]

Where,

SSE = residual sum of squares

m = number of restrictions

k = number of independent variables

n = an observation

OR,

$F = \sigma_1^2/\sigma_2^2$ ..... ……[Equation 3.9]

Where,

$\sigma 1^2$ = the population variance 1; and

$\sigma 2^2$ = the population variance 2.

Farmers' rainfall and temperature perceptions were analysed by use of thematic and descriptive statistics. Microsoft Excel was used preferred during the rainfall and temperature data analysis because it has an in-built tool and the ability to analyse data in form of graphs, charts and tables. It was also used to generate trends for 30 years' historical rainfall and temperature data.

e) Analysis of perceptions of farmers on climate change

Data collected from survey household questionnaires, FGDs, KIIs on perception of farmers on climate change, household characteristics and adaptation strategies to climate change and climate variability were also analyzed using descriptive statistics and presented in tables, charts and narratives. The statistical analysis of both qualitative and quantitative data was coded by

use of a computer. Descriptive Statistics (DS) such as percentages, frequencies and means were obtained, and where necessary relevant cross-tabulations were made. Further verification of household survey questionnaire data was achieved through comparing notes from the KIIs and FGDs. The analyzed data was then presented in tables, frequencies, figures, percentages and narratives.

Objective 2 - Determination of different livelihoods activities / Climate change and fluctuation have an impact on possibilities

3.5.5 Desktop studies

The information from the social survey on the impacts of climate change and variability on livelihoods in the study region was supplemented with published journal publications and reports. Literature from journals, Government reports in Africa) were also reviewed how climate change policies relate to ameliorating impacts and improving livelihoods

3.5.5.1 Fieldwork studies

a) Overview

On the dates specified in the study, a team of trained enumerators administered household survey questionnaires to heads of households. Specific households and areas were identifiedby the help of the village elders who also assisted in the identification of heads of households.In certain households (HHs) where the heads were adamant and refused to answer questionnaires, the enumerator would move to the next immediate household and continue with the exercise.

b) Household surveys

Data were collected through an approach that combined a household questionnaire survey (described in section 3.3.2.2 (b) above), but this part addressed the following parts of the questionnaire namely sections 1.2, 1.3, 1.4 and 1.6 (Appendix 01).

c) Focused Group Discussions

The focus groups were conducted as indicated in section 3.3.2.2 (c) above, and for this objective the focus was on sustainability of livelihoods based on questions 4-10 (Appendix 08). During the discussions participants were each granted an opportunity to answer each of the questions. Consensus was then reached to arrive at the strategy or policy. New adaptive strategies and

policies were formulated and domesticated to increase resilience and capacity, and at the same time reduce extreme climate change threats to livelihoods in the region.

(d) Key Informant Interviews

Further information was derived from six Key Informant and In-depth interviews (KIIs) with representatives from public and private organizations, and six In-depth Interviews with some respondents who comprised farmers, business men and women, the youth (see appendices 4 and 6, respectively), using the method described in section 3.3.2.2 (d) above. Much of the information from the KIIs would be used to build capacity as scientists and societal actors co-operate to overcome the disjuncture between knowledge production on one hand and demand for knowledge to contribute to solutions on the other hand.

3.5.5.2 Data analysis

Computers were used to code the qualitative and quantitative data, which were then analysed using IBM Statistical Package for Social Sciences (SPSS) version 23.0 and Microsoft Excel spreadsheets. Calculations were used to produce descriptive statistics such as percentages of responses, frequencies, and computed means, as well as applicable cross-tabulations where necessary. Further verification of household survey questionnaire data was achieved through comparing notes from the field and secondary information. The analysed data were presented as results in tables, charts, figures, and narratives.

3.5.6 Objective 3 – Examination of coping and adaptation strategies used by households

3.5.6.1 Desktop studies

Published journal papers, Government of Kenya reports, the internet and international agreements were used to complement the information from the climate data, and to review the impacts of climate change on livelihoods in the study area.

3.5.6.2 Fieldwork studies

a) Overview

As described in section 3.3.2.2 above, the same procedure was followed during collection of data by the enumerators. However, to achieve the findings of objective three (3) every research

participant was supposed to contribute towards the formulation of new adaptive strategies and policies. Thus, this approach had data collected from FGDs, KIIs, and household survey questionnaires analysed in order to achieve the stated objective. Mixes of quantitative and qualitative data collection methods were employed for more dependable and better findings. The recommendations included the blending of traditional and contemporary farming technologies. The talks were based on the sample questions in (Appendices 08, 09, and 10). Depending on how useful they would be in the future, traditional technologies were enhanced or abandoned entirely. Predictive analytics is used throughout the data analysis process to create scenarios that will guide future actions and events.

b) Household surveys

The household questionnaires were administered to heads of 32 households in each of the sub-locations (Appendix 01) for details translating into 398 in the whole study area. The questions that formed the basis of the household survey questionnaire dwelt mainly on land and farm use, food security, coping with weather related extreme events as in sections (1.2, 1.6 and 2.0). New adaptation methods and policies were developed and were to be domesticated in order to improve resilience and adaptive capacity in order to mitigate extreme climate change threats to the region's livelihoods. The structured survey questionnaires were used to learn more about how individual families were affected by climate change and to spark discussion about how to move forward with policy formulation that affects livelihoods.

c) Focus Group Discussions

Data was gathered using a method that combines discussions conducted as described in section 3.3.1.2. During the discussion, the main focus was on the kind of adaptive measures and policy suggestions that would be developed to help mitigate the effects of climate change. Another topic brought up was how residents were dealing with changing weather patterns. In the case study on how households and communities maintain and sustain livelihoods, coping and adaptation mechanisms were studied. The researchers wanted to know what people did during harsh weather and how communities supplemented their income from non-farm activities to adapt to climate change and variability at the household level.

The local people' perceptions of temperature and rainfall trends, agriculture systems, livestock rearing, poverty levels, and water supplies were gathered through Focus Group Discussions

(FGDs). The structured survey household questionnaires were distributed to heads of households across the study region with the goal of better understanding how individual households are affected by climate change while also participating in policy development. All of the actors were given the opportunity to talk and come up with cutting-edge solutions, as well as participate in the development of adaptive plans and policies that will strengthen the community's resilience to unforeseen events.

d) Key Informant Interviews

Key informant and in-depth interviews (KIIs) were conducted with key stakeholders (Appendices 4 and 6) who had relevant knowledge on how climate change and variability have impacted livelihoods in the research area. People with specific knowledge and experience of climate impacts on livelihoods were surveyed using KIIs. The aim was to supplement information obtained from FGDs and survey households the discussions and the interviews all actors were granted an opportunity to dialogue on the way forward on the sustainability of livelihoods and the long-term formulation of adaptive strategies and make recommendations to increase community's resilience and adaptive capacity. The KIIs interviews were carried out in the heads of department work place; the in-depth interviews were administered to respondents at their individual homes.

3.5.6.3 Data analysis

The study's major goal was to identify short- and long-term adaptation strategies to maintain development and improve livelihoods, as well as to increase resilience and adaptive capacity to cope with climate change consequences. The study looked at the communities in the study region from the perspective of people whose livelihoods are threatened by climate change and variability. During the research, research questions were answered utilizing a mixed method approach that included both quantitative and qualitative approaches, with the goal of collecting real-life experiences related to how climate change affects livelihoods. Both primary and secondary data were collected, coded, and analysed. The primary goal of data coding was to organize the information into categories by giving number codes to each. This entailed cleaning and manipulating the data before it could be analysed. Quantitative data was analysed and displayed in graphs, figures, and tables using the IBM Statistical Package for Social Science (SPSS) version 23.0, whilst qualitative data was analysed and presented in descriptive and theme

narratives.

Household survey questionnaires sought to understand how individual households experienced impacts of climate change on livelihoods in order to generate adaptive policies. Data analysis was mainly based on topical questions. The IBM Statistical Package for Social Science (SPSS) version 23.0 and Microsoft Excel spreadsheets were used to code and analyse the statistical analysis of both qualitative and quantitative data. Calculations were used to produce descriptive statistics such as percentages of responses, frequencies, and computed means, as well as applicable cross-tabulations where necessary.

Further verification of household survey questionnaire data was achieved through comparing notes from the field and recorded notes to capture the theme of the research in order to ensure that the data captured matched that that was recorded. The analysed data was then presented in tables, figures, charts and narratives.

3.5.7 Data synthesis

The main goal of this research was to determine the long-term effects of climate change on livelihoods and to develop solid policy suggestions to improve livelihoods and sustainable development. The first specific objective was to examine historical climate trends, variability, and villager perceptions; the second specific objective was to determine adaptive strategies used to maintain livelihoods impacted by climate change; and the third specific objective was to investigate coping adaptive strategies used by households to cope with climate change on livelihoods. Policy recommendations were developed during the research process to mitigate the effects of climate change on livelihoods and boost socioeconomic growth.

Climate change and variability can have a greater impact on communities that rely on rain-fed agriculture for their livelihood. Due to restricted access to climatic information, inadequate access to services, and unequal access to productive assets, communities in the research area have limited livelihood alternatives and low adaptive capacity. This research is being conducted in rural villages in the Kapsokwony Division of the Mt. Elgon Division, where little is known about adaptation methods that can be utilized to mitigate the effects of climate change on livelihoods. To obtain data / information from respondents to forecast the severity of climate change impacts on livelihoods, participatory research was used, which included the use of focus groups, interviews, and the administration of household survey questionnaires. The Kitale Meteorological Station provided secondary data, which was analysed for trends and variability.

Farmers' impressions of climate change and unpredictability were consistent with actual metrological data, which noted variations in season length, timing, and distribution. Statistical and descriptive techniques were used to conduct the data analysis.

Henceforth, the findings of the three (3) specific objectives were integrated to achieve main objective of the study. The generation of policy recommendations was based on the findings of the combination of data analysis of the three specific objectives 1, 2 and 3. The overlapping climate change trends and variability impacts in the study region include altered precipitation regimes and increased temperatures. The analysis found out significant variations in climate patterns are impacting crop and livestock production and thus the livelihoods of communities in the region. According to responses by farmers during FGDs and KIIs, rainfall had become unreliable and unpredictable while prolonged drought periods were leading to crop failure and lack of pasture. Livestock farmers in the region have reduced their herds and often some drive their animals into the forest for grazing and watering. Farmers who own woodlots sale timber and wood-fuel to earn some income and very few are engaged in agri-businesses.

CHAPTER FOUR: HISTORICAL CLIMATE DATA AND COMMUNITY PERCEPTIONS OF CLIMATE TRENDS

4.1 Introduction

This chapter presents key results of the analysis of 30 years' historical climate data in line with specific objective 1. The chapter also presents findings of climate data as well as villagers' perceptions presented in charts, tables and narratives. Towards the end of the chapter, discussion and conclusions were made.

4.2 Quality control

Homogeneity test checked for completeness and consistency in the rainfall and temperature data which resulted in the derivation of single mass curves plots generally straight single mass lines Figures 4.1 and 4.2 indicative of good rainfall and temperature records They together with Coefficient of Determination (CD), R^2 (all above 0.9999) indicate that the data was consistent and good for use in this research.

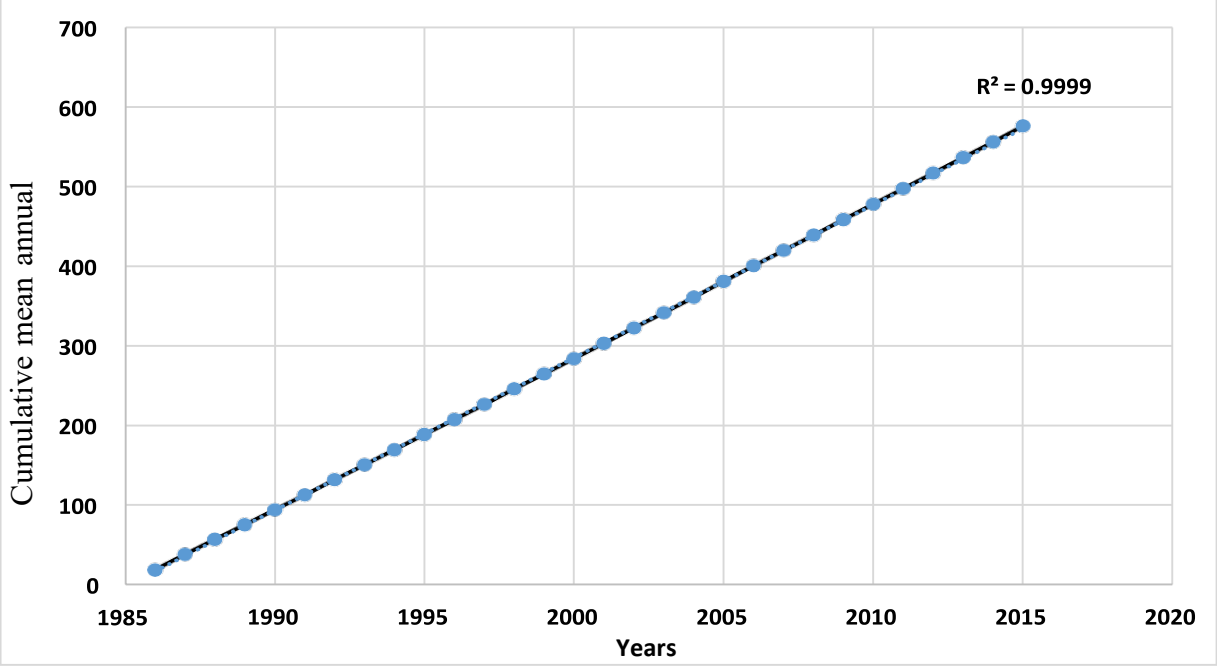


Figure 4.1: Single mass curve, cumulative annual rainfall for the study area (Source: Rainfall data 1986-2015 from KMS)

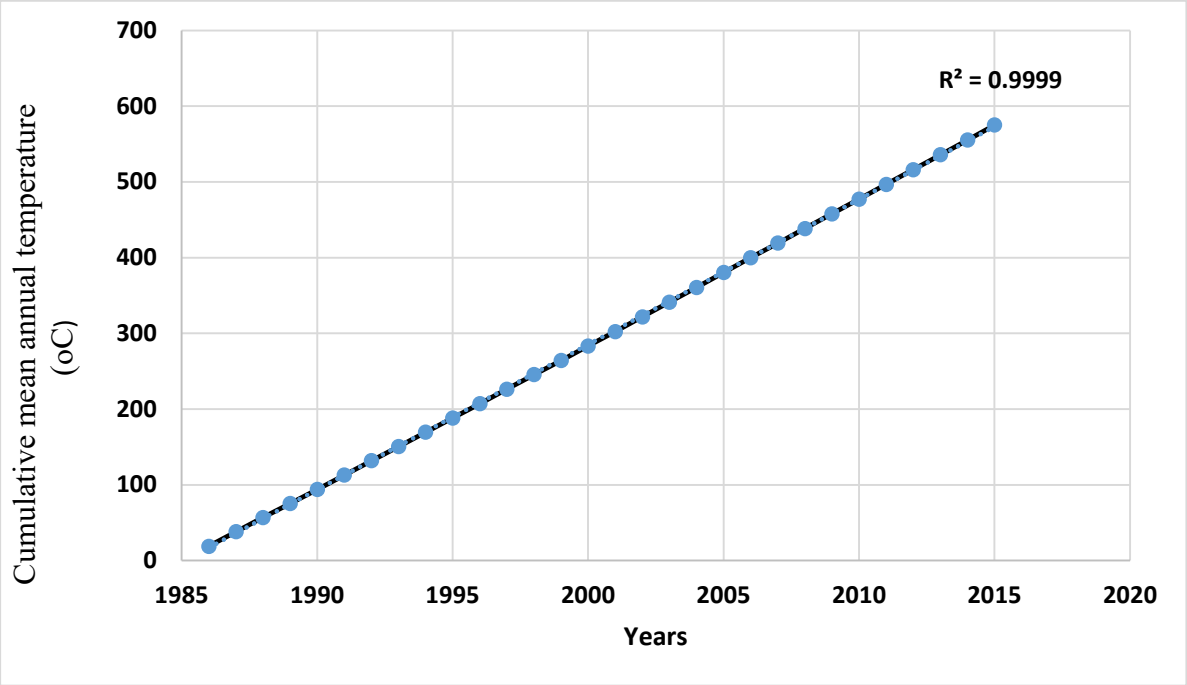


Figure 4.2: Single mass curve, cumulative annual temperature for the study area

(Source: Temperature data: 1986-2015 from KMS)

4.3 Rainfall results

4.3.1 Dry and wet years

The results for Standardized Anomaly Index (SAI) for the study area are presented in Figure 4.3. Notably, the eight (8) wettest years on record were; 1997, 2001, 2006, 2007, 2010, 2011, 2012 and 2013 with SAI values above 1. The driest three 3 years were; 1986, 1999 and 2005. The years that received normal rainfall were (10) years including 1987, 1991, 1992, 1993, 1994, 1995, 1996, 1997 1988, and 1989. The remaining (9) years 1988, 1989, 1990, 1999, 2002, 2003, 2004 2014 and 2015 years had moderate rainfall. The results for the rainfall data show irregular distribution of precipitation. When these trends were computed, it was foundout that the MAM trends (<0.05 or 5%) had significantly decreased whereas the OND trends (>0.05 or 5%) had significantly increased. respectively.

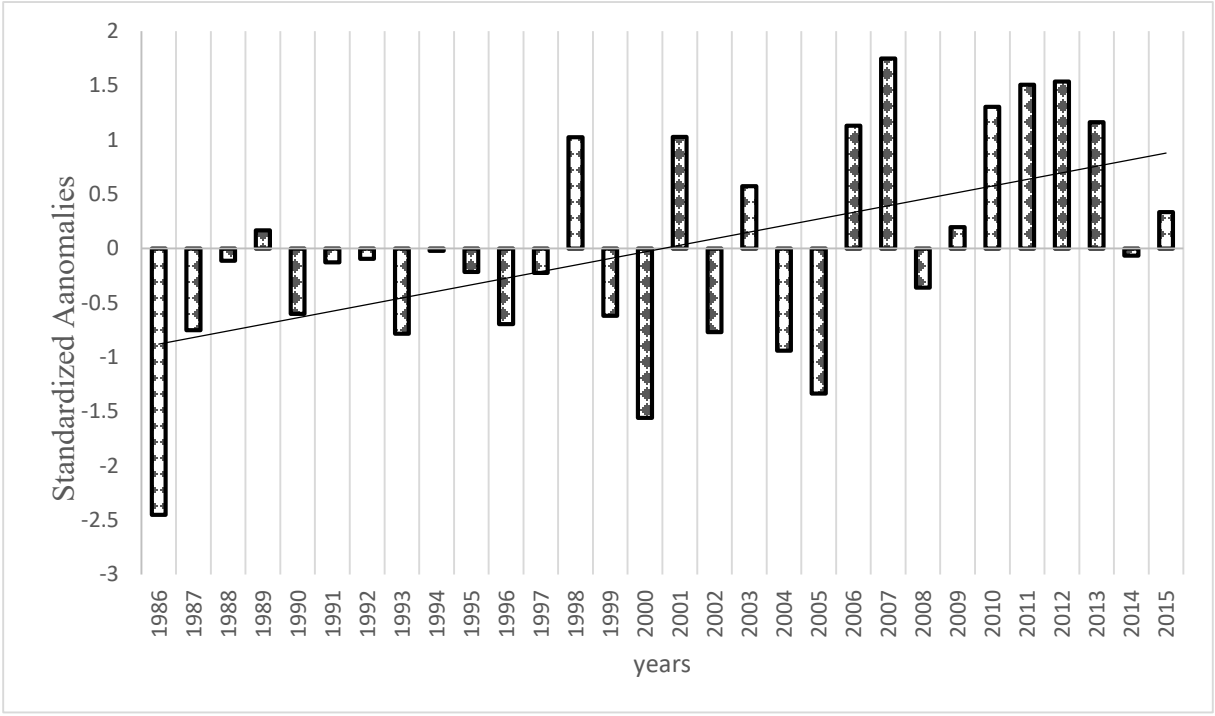


Figure 4.3: Dry and wet years (Source: Rainfall data 1986-2015 from Kitale Meteorological Station)

4.3.2 Average monthly rainfall and temperature series

Figure 4.4 indicates that the station receives three (3) peaks of rainfall (tri-modal) and the highest rainfall was received in the month of April with a monthly average of 180 mm. and the second highest in the month of August 145 mm while the third peak was realized in the month of October 130 mm. (Figure 4.4). The temperature range is small (about 3°C) with highest temperature observed in the month of February, a month after maximum solar intensity and the lowest temperature is observed in the months of June, July, and August (JJA).

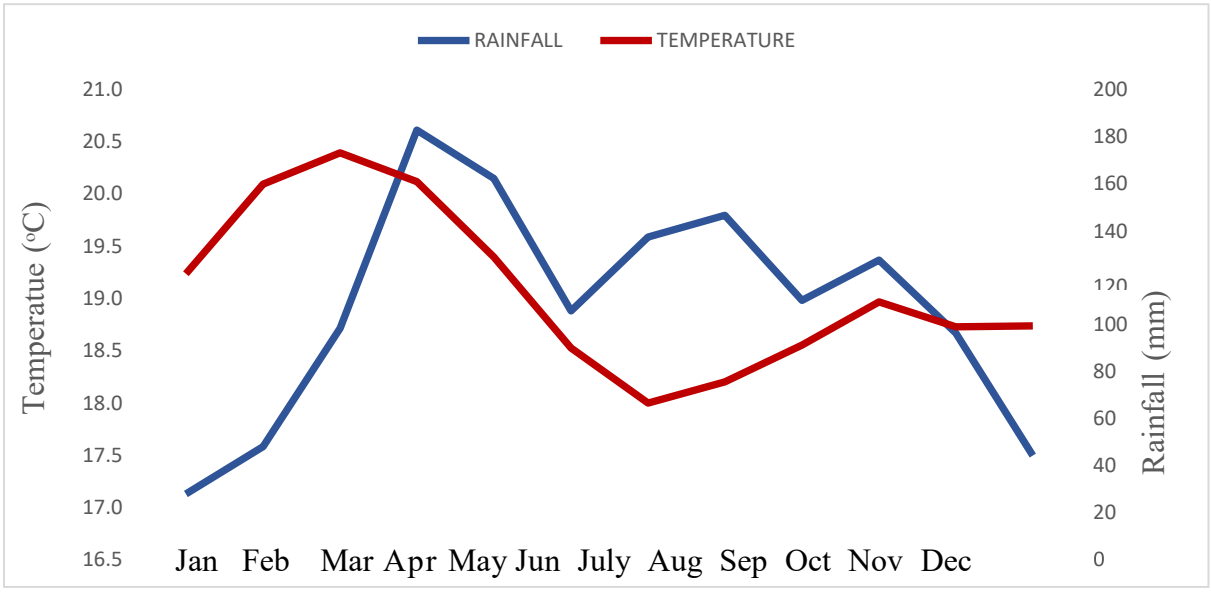


Figure 4.4: Average rainfall and temperature series (Source: Rainfall and Temperaturedata 1986-2015 from KMS)

4.3.3 Annual average total rainfall

Figure 4.5 depicts seasonal and annual rainfall trends. From 1986 to 2015, the rainfall trend has been increasing, but the trends have gotten more erratic. Between 1997 and 1998, there was an upward tendency that was attributed to the *El Nino* phenomenon. From the year 2005 to 2007, an upward trend in amount of mean annual rainfall was recorded while a slight fall was recorded in 2008. Another upward trend was experienced between 2009 and 2010 yet a constant amount of mean annual rainfall was experienced between 2011 and 2012. A drastic drop in rainfall amount was recorded between 2013 and 2015.

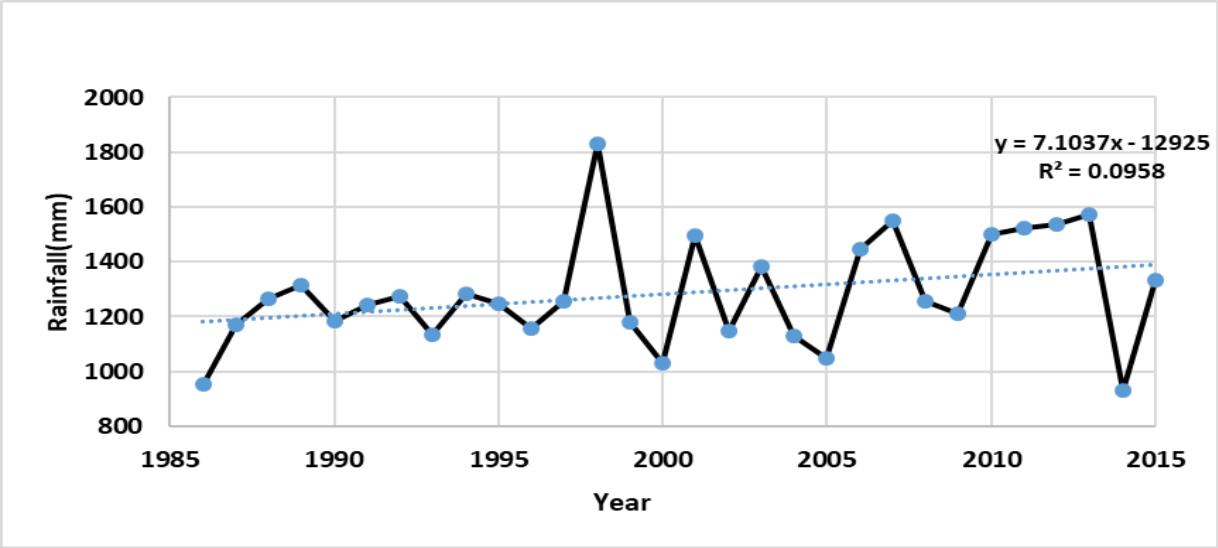


Figure 4.5: The average annual rainfall for study area from 1986 - 2015 (Source: Figure generated by S. B. using 'Microsoft Excel').

4.3.4 The MAM rainfall trend

MAM trends from 1986 to 2015 are depicted in Figure 5. The MAM trend displays the annual rainfall in millimeters. The MAM rainfall trend has been steadily increasing, with the highest amount of 750 mm being recorded in 2015. With a positive slope of 9.96 and a weak coefficient of determination (R2) of 0.28, the annual rainfall trend has been increasing. The MAM trend stayed unchanged, whereas the OND trended upward.

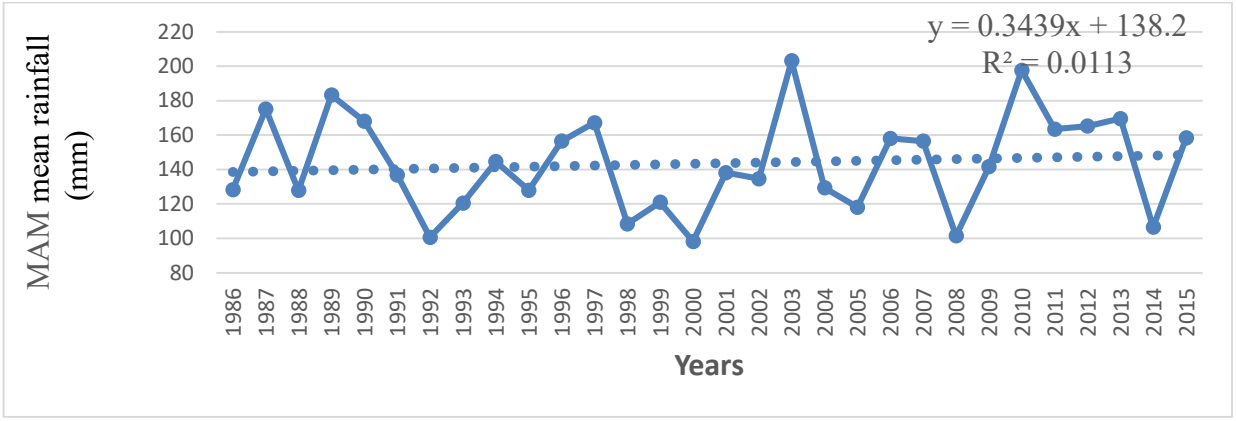


Figure 4.6: The MAM rainfall trend for 1986 to 2015 period (Source: Figure generated by S. B. using 'Microsoft Excel').

4.1.4 The OND rainfall trends

Figure 6 OND depicts the changing rainfall pattern, with the highest annual rainfall of 450 mm recorded in 2009. With the passage of time, the OND tendency has accelerated. The F-test, however, reveals that the increases in trends are not significant because the p-values were greater than the level of confidence (5%).

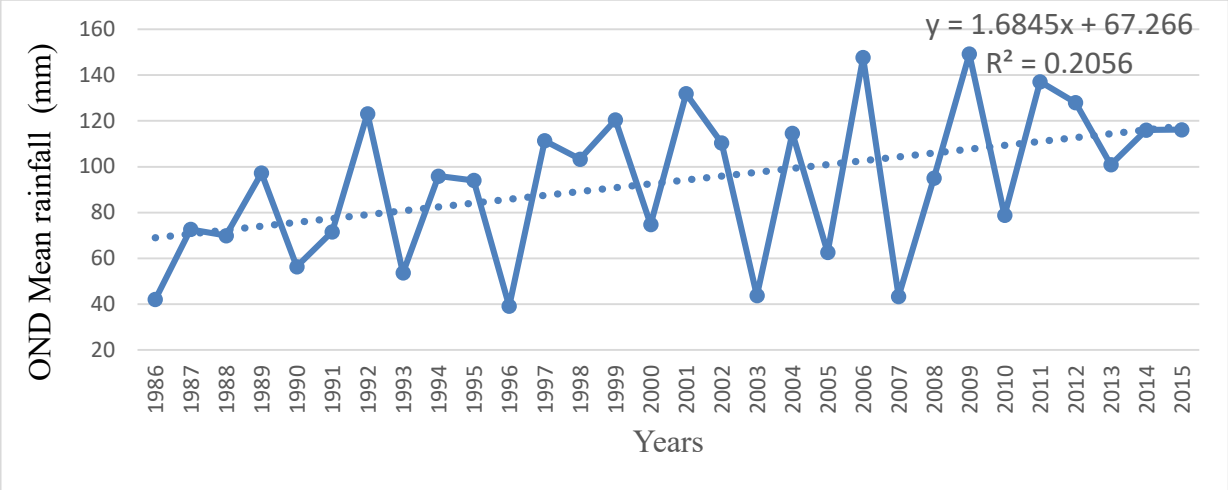


Figure 4.7: The OND rainfall trends for the 1986 to 2015 period (Source: Figure generated by S. B. using 'Microsoft Excel').

4.3.4 The MAM and OND rainfall trends

From Figure 4.8, the trend of annual rainfall has been increasing generally indicate by a positive slope of 9.96 but with a small coefficient of determination of 0.28. The MAM trend has been stationary while OND trend has been increasing over time. However, when testing for the significance of these trends (R^2) with the F-test, it was revealed that the increase in trends is not significant as the p-values are larger than the level of confidence (5%). This is as the effect / influence of the climate system of the Indian Ocean Dipole (IOD) as referred to by meteorologists. A positive Indian Ocean Dipole indicates a wetter west and dryer east, resulting in a wetter west and drier east causing a lot of disaster of alternating floods and droughts meaning that when one season is highest the other would be lowest (warmer than average and cooler than average). This means that, in comparison to the western half of the Indian Ocean, temperatures in the eastern part of the ocean vary between warm and cold. As seen in Figure 4.8, this occurred in 1992, 2003, 2010 and 2014.

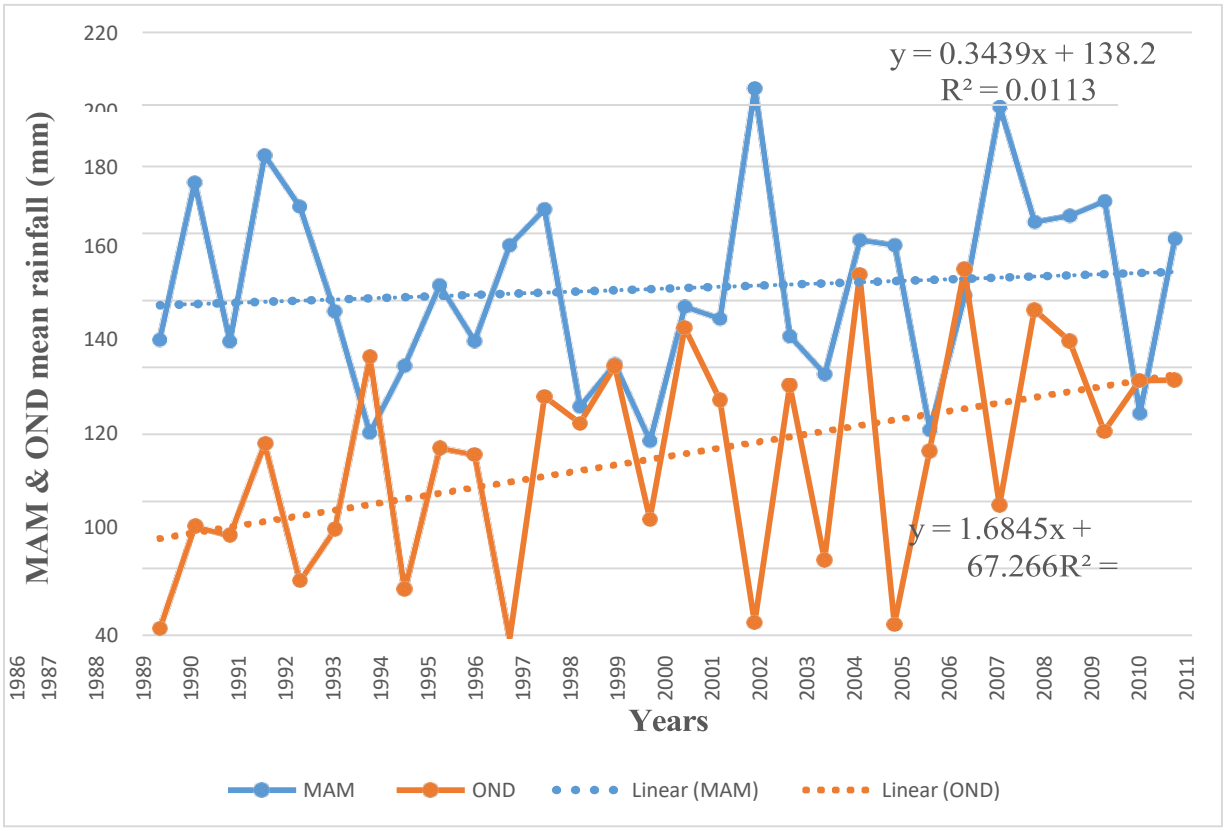


Figure 4.8: MAM and OND mean rainfall trends from 1986 to 2015 (Source: Rainfall and temperature data 1986-2015 from Kitale Meteorological Station)

4.3.5 Rainfall variability

The data was divided into two equals so that variability could be calculated samples to find whether any changes in trends were within seasons (Table 4.1). It is evident that the annual amounts of rainfall increased for the first 15 years and decreased in the last 15 years respectively as depicted by the two means sets (114.29 mm and 101.24 mm). However, the rainfall in the study area is less variable as shown by the low values of standard deviations. Kurtosis (measurement of how values are bundled in relation to the center of distribution) and skewness (a measure of the symmetry of a distribution) values are relatively low indicating normal distribution of rainfall across the study area.

Table 4.1: Descriptive statistical analysis of two rainfall data sets of 15 years each for annual series

Variation 1	Annual	Variation 2	Annual
Mean	114.29	Mean	101.24
Standard Error	3.53	Standard Error	2.64
Median	121.25	Median	104.18
Mode	N/A	Mode	N/A
Standard Deviation	13.68	Standard Deviation	10.22
Sample Variance	187.08	Sample Variance	104.44
Kurtosis	-0.99	Kurtosis	3.82
Skewness	-0.61	Skewness	-0.99
Range	42.27	Range	47.59
Minimum	88.87	Minimum	73.66
Maximum	131.14	Maximum	121.19
Sum	1714.42	Sum	1518.58
Count	15	Count	15

4.4 Temperature trends

The analysis of temperature data for 1986-2015 period was carried out in excel and the results were presented graphically as shown in Figures 4.11, 4.12 and 4.13. The year 2015 recorded the highest observed temperature of 20°C. Upon checking the significance of the trend, it was noted that the increase is significant at 5% level of significance, implying that the results support the analogy of climate change.

4.4.1 The annual temperature trends from 1986 to 2015

Figure 4.9 indicates that the trend of temperature has been increasing from 1986 to 2015 with 2015 as the year with highest observed average temperature of about 20°C.

Figure 4.9: Annual temperature trends from 1986 to 2015

(Source: Temperature data for 1986-2015 from Kitale Meteorological Station)

4.4.2: The MAM temperature trends from 1986 to 2015

Figure 4.10 indicates the MAM temperature which has shown an increasing trend for 1986-2015 period with the highest mean temperature being observed in the year 2001.

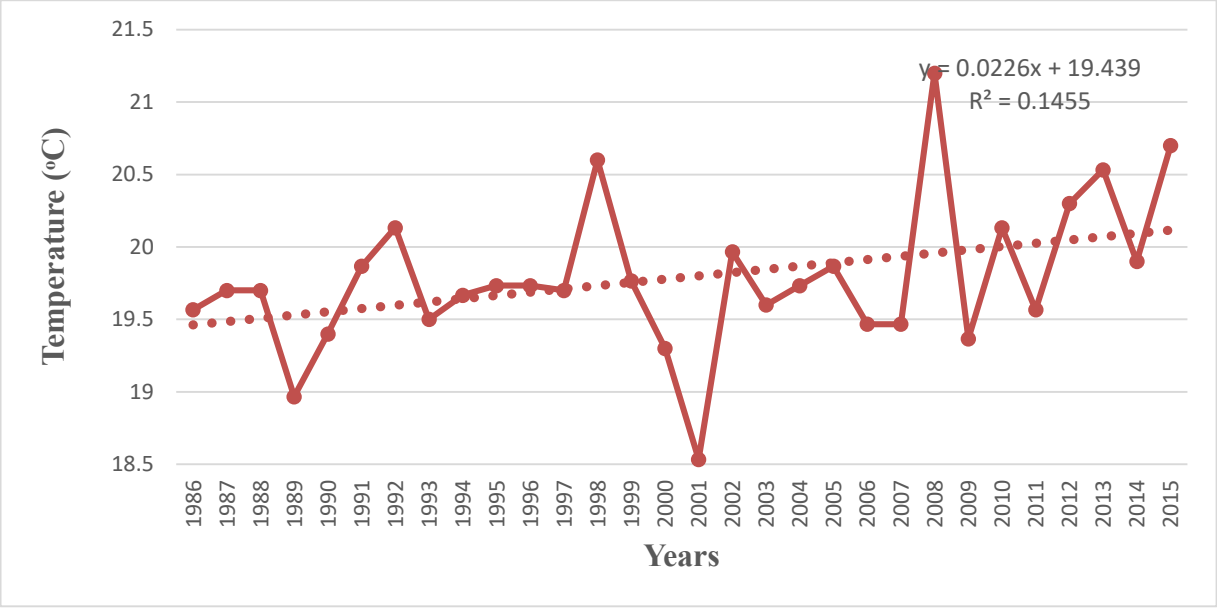
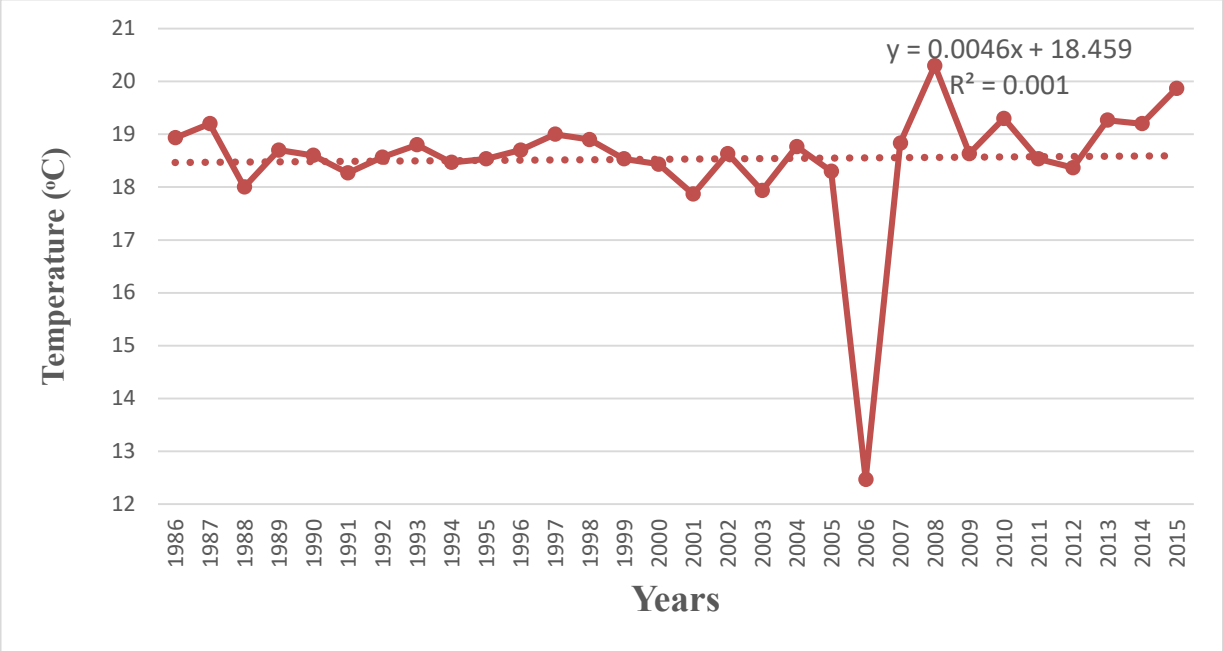


Figure 4.10: The MAM temperature trends from 1986 to 2015

(Source: Temperature data for 1986-2015 from Kitale Meteorological Station)

4.4.3: The OND temperature trends from 1986 to 2015

Figure 4.11 shows the OND temperature trends for the 1986 - 2015 period. The results depict lots of fluctuations over the time series dipping steeply in from 2012 from 19.3°C to 18.2°C before increasing to 18.4°C in 2015. However, temperatures have been increasing over the period. In 2006, a temperature was experienced marking a negative anomaly / or departure from the baseline indicating that the observed temperature was cooler as compared to the baseline or the normal average. This is because by modifying the transfer of latent and sensible heat from the ocean, the Sea Surface Temperature Anomalies altered the atmosphere and thus, providing anomaly heating patterns.



Figures 4.11: The OND temperature trends from 1986 to 2015

(Source: Temperature data for 1986-2015 from Kitale Meteorological Station)

4.5 Characteristics of the respondents

4.5.1 Sex of the respondents

Respondents to the livelihood questionnaire in this study were between 35 to 60 years and were both men and women. According to the results of the household survey, the vast majority of respondents were male making a total of (n = 210, 53.13%) while females were (n = 188, 46.88%). This clearly creates a difference of about 6.25% as shown in Figure 4.12. When women

respondents were asked about the whereabouts of their male counterparts, the common reply was that men were absent for one reason or the other.

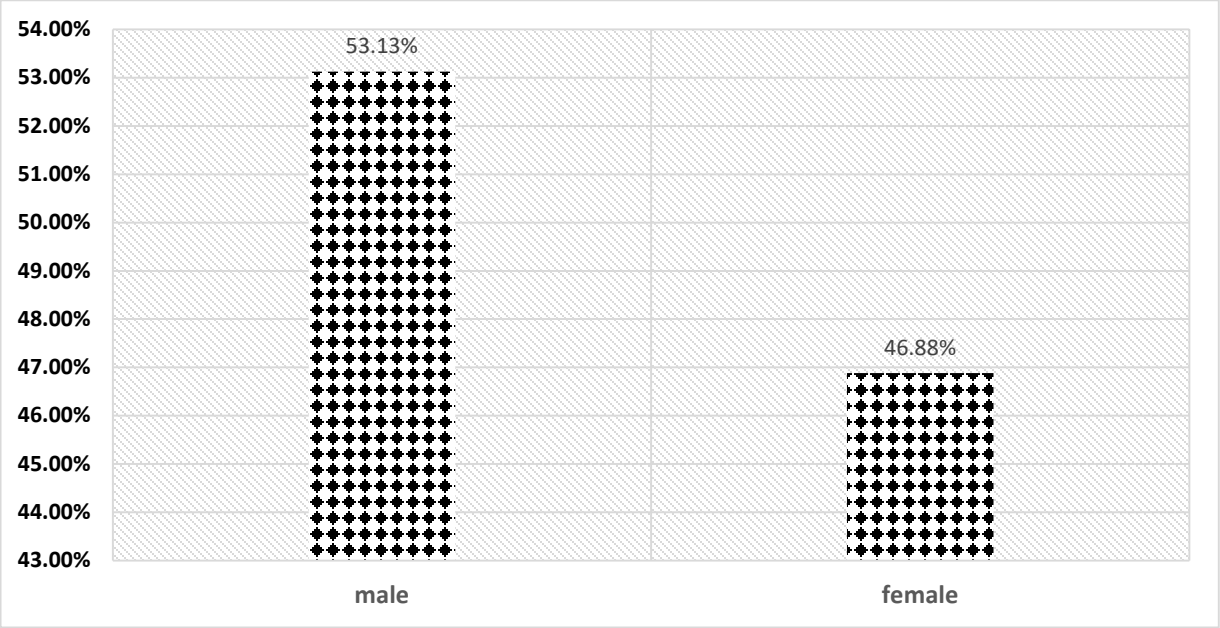


Figure 4.12: Sex of the respondents

4.5.2 Marital status

Figure 4.3 shows that from the survey conducted, a t majority of the respondents (n = 271, 70%) were in a monogamous marriage set up followed by polygamous (n = 59, 15.36%) making a total of (n = 330, 85.94%). Those widowed were (n = 33, 8.59%) whereas the remaining were single (n = 18, 4.69%) and those who had separated or divorced were (n = 3, 0.78%) making a total of (n = 21, 5.47%). Respondents in monogamous marital status tend to consult and easily agree on various family issues than those in either polygamous or single marital status because of the cohesion within the families. The region was also noted to have farmers who profess Christianity as shown in (Table 5.5) below constituting 100 % of the respondents.

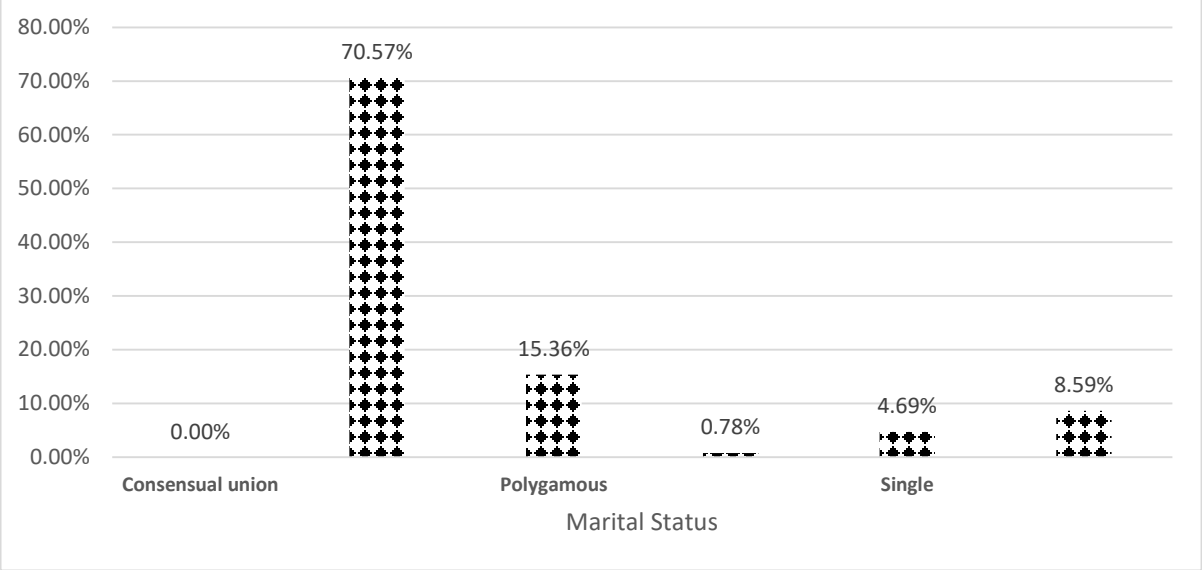


Figure 4.13: Marital status

4.5.3 Education of respondents

The majority of the respondents had acquired formal primary education, (n = 194, 48.74%) while those who had acquired secondary education were (n = 140, 35.17%) as depicted in Table 4.3. The display of results in the same Table 4.3 shows that (n = 17, 4.27%) of the respondents had acquired no education. Those who had attained technical or vocational education represented only (n = 16, 4.02%) of the respondents while those who had attained tertiary education were (n = 25, 6.28 %) of the total respondents. Overall, respondents' literacy levelsin the research area were poor.

Table 4.2: Education of respondents

Education of respondents	Frequency	Percentage (%)
Literacy Course	6	1.56
None	17	4.27
Primary	194	48.74
Secondary	140	35.17
Technical/Vocational	16	4.02
Tertiary	25	6.28
Total	**398**	**100.00**

4.6 Community climate perceptions

4.6.1 Respondents' rainfall perceptions

To capture community's perception on rainfall variability, in order to grasp the villagers' views on climate change, a series of questions about it were included in the household questionnaire views on rainfall variability. The majority of respondents (90 percent) have noticed changes in rainfall patterns, according to the distribution of responses while (10%) had not. Table 4.3 shows the distribution of respondents based on community perceptions on rainfall variability.

Table 4.3: Community perceptions of rainfall

	Number of Respondents	Percentage (%)
Yes	352	90
No	46	10

Smallholder farmers in the study region accounted for 352 (90%) of the total respondents who perceived changes in rainfall, whereas those who did not accounted for 46 (10%) of the total respondents. The ages of the people who were interviewed ranged from 35 years to 60 years. Similarly, about 90% of the respondents reported that changes in the weather patterns threatened their livelihood activities.

4.6.2 Respondents' temperature perceptions

Most farmers in the household questionnaires (80%) and in the Focus Group Discussions (FGDs) (100%) unanimously concurred that temperature in the region had significantly risenin the last three decades. This could be attributed to conversion of the natural landscape to agricultural land, human settlement, logging, deforestation and decimation of the ecosystem. In the view of FGDs, all the participants from the three (3) FGDs concurred that region has become hotter in recent years as compared to 30 years ago?

In a Focus Group Discussion 1 (FGD1), a woman named said:

"Since I was born in 1950, I have never experienced such hot temperatures….and on

agriculture; I had a very fertile piece of wetland land which I ploughed year in year out, and about 2010. As per now the wetland has dried up due to increasing temperatures…. (FGD1).” Another participant in a Focus Group Discussion 2 (FGD2) added something to the conversation: *“It seems that the sun is moving closer towards the earth judging from the wayit is hot.”* Participants in the three focus group talks all agreed that the temperatures had risen over time.

Data gathered through household questionnaires were used to corroborate the views gathered from FGDs. Respondents in the household survey were asked to describe the state of temperature variations in their location using one of three (3) options: 'increasing,' 'decreasing,' or 'not changing.' About 80% of the respondents reported that temperatures had increased while only 20% said that temperatures had decreased. Study findings by Amwata *et al.,* (2013) in Makueni and Kajiado Counties that consider the effects of climate change on livelihoods demonstrate how anthropogenic effects are driven by environmental resource degradation of the lives of the rural poor.

4.6.3 Participants’ climate perceptions

Significant changes in the frequency and severity of climate events, as well as their impacts on crop production, livestock, food prices, and health, were reported by participants in the household questionnaire survey, key informant interviews, in-depth interviews, and focus groups. Significant changes in the frequency and severity of climate events, as well as their impacts on crop production, livestock, food prices, and health, were reported by participants in the household questionnaire survey, key informant interviews, in-depth interviews, and focus groups, according to the number of respondents representing smallholder farmers in the study area. The respondents' perceptions were captured in a variety of ways. About 352 (90 percent) of the total respondents thought variations in rainfall were significant, while 46 (10 percent) did not.

During an in-depth conversation with a traditional weather specialist, the prevalent notion of increased flood frequency and intensity was confirmed:

> *"Rains have become unreliable and un-predictable and temperatures have increased over time. Farm productivity has greatly decreased as compared to the past decades. The water catchment has been tampered with resulting in threats to livelihoods. Further, this has been exacerbated by fragmentation of land as a result of exponential population increase. The levelof poverty at household levels has increased."* **In-depth interview with a traditional weather expert on 15th February, 2016.**

During an informant interview with another traditional weather expert, the general opinion of rising flood frequency and intensity was confirmed:

> *"Climate change is taking place mainly as a result of human activities as perceived in the environment. These activities include encroachment on the forest ecosystem, conversion to farmland and human settlement, overgrazing, poor agricultural practices, charcoal burning, fuel-wood collection, deforestation, water pollution and urbanization. This has resulted in altered rainfall patterns and increased temperatures. The rains either come too early or too late and therefore the farmers cannot know when to plant. Heavy rains during harvesting periods destroy the crops due to either diseases or decomposition. Crops ripen earlier than expected because of increased temperatures. Starvation and malnutrition are common during certain months of the year in the region."* **Informant interview with the Head of Biko Kapkoret (BK) radio station on 16th February, 2016.**

The Deputy District Education Officer was interviewed and she had this to say about the changing scenario in climate change in the region:

"The region has become warmer than ever before and rainfall unreliable and unpredictable. Farm products have declined over time and food insecurity has become a major issue in the region. Limited pasture in the villages has forced families to drive their livestock to graze inthe forest. Some children have been forced to drop out of school because they have to drive the animals to the forest for pasture and watering. Some schools in the region have been able to establish tree nurseries as an income generating activity." **Informant interview with DEO Kapsokwony Sub – county on 20th February 2016.**

A decrease in cropping output highlighted the effects of climate change and variability, food insecurity, increase in poverty levels, decrease in pastureland, abstraction of water quantity and quality standards, changes in land use and environmental degradation.

Over 90% of the farmers interviewed had perceived change in the rainfall patterns as far back as 15 to 20 years. Generally, farmers' reported late onset of rain, poor distribution within the season, and sometimes early cessation. In particular, they noted that the planting season had shifted from early March to late March or early April and now end in June rather than May. In the last 10 years' farmers' highlighted specific problems of variability in the duration, timings, and intensity of the rains. For example, heavy rainfall occurred at the start of the seasons in 2005, 2007 and 2010. In some parts of the study area especially on the slopes, farmers said that there was an increasing problem of flash floods as a result of enhanced rainfall which has also resulted in water logged soils and landslides. From the respondents' perspective there is a paradigm shift in rainfall due to climate change.

As noted during Informant interview with the District Agricultural Crop Officer Mt. Elgon District on 7th February 2016

"There has been a paradigm shift in the rainfall patterns in the region because of climate change. For instance, in 2014 the rains experienced during the long rain period were very heavy whereas those experienced during the short rain period were very low. The situation was vice versa in 2015. The dry spell experienced in 2015 caused the perennial tree crops tea and coffee to wither. The El Niño on set in October 2015 to February 2016 complicated matters for farmers." **Informant interview with the District Agricultural Crop Officer**.

Focus Group Discussions (FGDs) held with the youth representatives on 24th June 2016 who

stated unanimously as follows:

"This is mainly due to altered rain patterns, increasing temperatures, diminishing water quantities and decline in pastureland. Impacts of climate change have greatly reduced income at household levels causing unemployment, rising poverty, insecurity, high food prices, waterborne diseases and under-nourishment among children. The movement of animals into the forest is an adaptive strategy to enable farmer's access pasture and water." **FGDs conducted for all the youth representatives in the study area on 24th June, 2016**.

4.7 Discussion

The mountain slopes and the complex terrain which characterize the study area greatly affect the local climate, as is common for mountain regions (Platts *et al.,* 2015; Taylor *et al.,* 2006; Buytaert *et al.,* 2011; Olago *et al.,* 2015; FAO, 2015;). Generally, the research results in the study region depict a rise in average annual rainfall by (60 mm) each year and an increase in average temperatures by 1.0°C. These findings are statistically significant, showing that climate change is occurring in the research area and affecting people's livelihoods. Though the study area experiences adequate and desirable rainfall to support agriculture, the present study findings reveal that there are significant variations according to research, in its distribution on annual and seasonal scales (Kansiime, 2010). The tri-modal rain patterns (Figure 4-4) are due to the fact that the study area is under the influence of the surface air masses from Equatorial Congo rain forest, Mt. Elgon Forest as well as its nearness to Lakes Victoria, Turkana, Albert and Kyoga (Kansiime, 2010).

Annual rainfall trends based on parametric (linear regression) and non-parametric (F-test) statistics were statistically significant. On the seasonal scale, MAM trends have been declining, while OND rainfall trends have been increasing both which are statistically significant (Figures 5 and 6). These trends are coherent with other studies in the tropical mountains the world over (e.g. Camberlin and Philipon, 2002; Funk *et al.,* 2010). The study showed that seasonal rainfall variability is higher than annual variability (Table 1), and there is also high rainfall variability within seasons. Other studies reported in a Uganda government report (GoU, 2007) also back with these findings, demonstrating that inter-annual rainfall is increasing whereas MAM rainfall is decreasing and increasing trends in OND rainfall suggesting that these trends are uniform over the mountain, on both its eastern (study area in Kenya) and western (Uganda) aspects. These

results agree with some of the studies on the increased variability of Kenya's spatio-temporal rainfall distribution (Camberlin and Philipon, 2002; Funk *et al.,* 2010), as well as the observed in the East African mountain regions, the long rains (MAM) are decreasing while the short rains (OND) are increasing (Lyon and Debitt, 2012; Viste *et al.,* 2013; Liebmann *et al.,* 2014), and more generally, in many other non-mountainous regions of eastern Africa (Shisanya *et al.,* 2011; Mutai *et al.,*2000; Schreck and Semazzi, 2004). This has resulted in enhanced droughts that are impacting agricultural systems resulting poor food production resulting in famine and poverty that affect thousands of people living in the region (NCCAP, 2018). More generally, a number of other studies have also shown that there is a decrease in the long rains (MAM), maybe due to land-use changes in and around East Africa (EA) (IPCC, 2007; (Olago *et al.,* 2015; Kansiime, 2010).

Warming temperatures are already having an impact in the research area. The results indicate that the mean annual temperature trends (Figures 4.9), MAM mean temperature trends (4.10) and the OND mean temperature trends (4.11) over the period 1986 – 2015 have statistically significantly increased but with fluctuations over the time series. These findings are in line with prior temperature trend studies by King'uyu *et al.* (2000); Anyah and Semazzi (2006); and Omondi*et al.,* (2013). Similarly, the Horn of Africa region is experiencing an increase in warm temperatures, particularly at night, while cold extremes are diminishing. Similar observations related to increasing temperature trends have been recorded in rural and remote mountainous Jumla District in Nepal (Narayan, 2012) the Swiss Alps, the Andes and Sumatra mountains, Futa Jalon mountains and other mountain regions of the world, indicating that warming is a consistent global response to greenhouse gas emissions (Cook and Vizy, 2013; Omondi *et al.,* 2013).

In the last three decades, near-surface temperatures have risen by around 0.8ºC. in the East African region but studies show 2006 was an exceptionally cool as compared to other years. In 2006, a cool temperature was experienced thus marking a negative anomaly / or departure (Figure 4.11) from the baseline indicating that the observed temperature was cooler as compared to the baseline or the normal average. This is because anomalies in Sea Surface Temperature (SST) altered the atmosphere by changing the flux of latent and sensible heat fromthe ocean, resulting in anomalous cooling patterns (King'uyu *et al.,* 2000; Mutai *et al.,* 2000). Probably, the data coverage might have been inadequate / insufficient for researchers to draw significant conclusion about surface temperature in the region in 2006. The abnormal cooling might also

have been caused by abnormal climate variability associated with atmospheric air mass movements over large distances or areas. Previous observations by (King'uyu *et al.,* 2000; Mutai *et al.,* 2000; Hastenrath *et al.,* 2011; Omondi 2013; Cook and Vizy, 2013) in various regions of East Africa Mountains confirm the findings *et al.,* of this study that incluse the Ethiopian highlands, the Ruwenzori and the Kilimanjaro mts.

Generally, farmers reported a late start to the rainy season, poor distribution throughout the season, and sometimes an early end. The start of the planting season has slipped from early March to late March or early April, according to them. In the period 1986 – 2015, farmers have emphasized specific issues with rainy season variability in terms of duration, timing, and severity, as well as severe rainfall in the start of seasons like 2007, 2005, and 2010. In some parts of the study area, farmers said that there was as a result of increased rainfall intensity, flash floods are becoming more of a problemwhich has also translated into mudslides and landslides. According to the respondents'perspective, climate change has caused a shift in rainfall patterns as well as an increase in surface temperature as at now relative to the past decades. The community's impression of changes in rainfall patterns matched observational data, with respondents acknowledging late and sometimes early arrival of rainfall, mid-season droughts, and early cessations. The research revealed that changes in weather patterns in the study area negatively impacted agricultural systems, decline in water resources, increase in poverty levels, and socio-economic development leading to low standards of livelihoods. Under a changing climate, yields fromthe cropping systems and livestock rearing are threatened thus impacting livelihoods. The degradation of water systems may impact agriculture systems, health and sanitation. Climate change and variability, poor farming systems, natural resource over-use, population increase poor farming systems, stress of water resources and lack of transformation knowledge will culminate into many socio-economic stresses in the future.

Rainfall variation and an upsurge in surface temperatures has negatively impacted agricultural systems, water resources and general socio-economic development hence, livelihoods. The local community reported higher temperatures which are impacting stream flow and soil water content resulting in poor crop production and regeneration of pasture. Climate change has a negative impact on natural resources and ecosystem services, putting people's livelihoods in jeopardy and raising poverty levels. Trevors *et al.,* (2012) pointed out that ecosystem health and services give prospects for long-term socioeconomic prosperity as well as protection against the detrimental

effects of climate change on livelihoods. The degradation of ecosystems increases the vulnerability of communities living near them due to climate change, as well as the ecosystems themselves. According to related studies by Rowel *et al.,* (2015), East Africa and analogous tropical regions for instance the Ruwenzori, the Aberdares, the Mau and the Kilimanjaro Mountain regions have lately been hit by a succession of disastrous droughts, and forecasts indicate increased rainfall in the future decades, posing questions about potential adaptation alternatives.

Most farmers in the household questionnaires (80%) and in the Focus Group Discussions (FGDs) (100%) unanimously concurred that temperature in the region had significantly risenin the last three decades (1986-2015). This could be attributed to conversion to agricultural land, human settlement, illegal logging, fuel wood collection, degradation and decimation of the ecosystem. Floods, droughts, and landslides are all reported to be on the rise as a resultof climate change. Farmers' perceptions of climate change are consistent with climatic data on rainfall timing and distribution within seasons. This is a typical finding in other studies of resource users' perceptions of climate change, such as in Ethiopia's Nile basin (Deressa *et al.,* 2008), where farmers reported increasing variability in rainfall and shifts in growing seasons. The growing season is said to be shrinking and the distribution rainfall affects decisions made by farming household on what types of crops to grow and the land management to adopt (Komutunga and Musiitwa 2001). From the ongoing discussion, trend analysis studies for both rainfall and temperature and villager's perceptions conducted in the study area are not conclusive and hence, further research is needed. The study found that focusing solely on yearly or seasonal trends can be misleading, and that variability analysis and farmer perception should be used to back up the findings. For agricultural activities to succeed, seasonal reliability of rainfall is more significant than yearly reliability (King'uyu *et al.,* 2000; NMA, 2007; Belay *et al.,* 2014).

According to respondents during FGDs and KIIs, climate related disasters such as floods, droughts and landslides are said to be on the increase. Farmers' perceptions of climate fluctuation are consistent with climatic data on seasonal timing and distribution. This is a typical finding in other studies of resource users' perceptions of climate change, such as in Ethiopia's Nile basin (Deressa *et al.,* 2008), where farmers reported increasing variability in rainfall and shifts in growing seasons. The growing season is said to be shrinking and the distribution of rainfall has an impact on farming households' decisions about what crops to cultivate and how to manage

their property (Komutunga and Musiitwa 2001). Trend analysis research have emerged as a result of the current debate for both rainfall and temperature and villager's perceptions conducted in the study area are not conclusive and hence, further research is needed. The study found that focusing solely on yearly or seasonal trends can be misleading,and that variability analysis and farmer perception should be used to back up the findings. For agricultural activities to succeed, the seasonal consistency of rainfall is more crucial than the annual consistency (King'uyu *et al.*, 2000; NMA, 2007; Belay *et al.,* 2014).

4.8 Conclusions

The current study looked at historical climate data for trends and variability, as well as villagers' perceptions, from 1986 to 2015. Significant differences in rainfall and temperature trends and variability were discovered, which were most likely due to an increase in annual rainfall extremes and a rise in surface mean temperatures, influencing climatic patterns. According to trend study, the region has experienced significant irregularity in rainfall patterns and a spike in temperature during the last three decades. From 1986 to 2015, the current study examined historical climate data for trends and variability, as well as villagers' impressions. The analysis indicated significant differences in rainfall and temperature trends and variability which was likely attributable to an increase in extremes of rainfall on the annual scale and an increase in surface mean temperatures therefore changing climate patterns. In the last three decades, the region has seen significant irregularity in rainfall patterns and a rise in temperature, according to trend research. Similar studies conducted in mountainous ecosystems of the world are in agreement with the findings of this study, which show that rainfall patterns and variability are increasing (Camberlin and Philipon, 2002; Funk *et al.,* 2010).

This study's findings have the following implications: Significant trends and variability in rainfall have an impact on crop production (maize, beans, potatoes, and onions), with total crop failure occurring in extreme circumstances due to extended droughts or when floods wash away the crops. Farmers' educated farming decisions are highly influenced by a rise in the magnitude of annual rainfall, a decrease in MAM rains, and an increase in the OND rainfall pattern. Because of diminishing pastureland, protracted drought, and increased cattle diseases, as well as human exponential population growth, livestock farming has a grim future. This could result in a large reduction in the economy in the region as a result of lost opportunities for farmers to earn a substantial income. If achieved, the wasted opportunity would inject cash

into the veins of the rural economy, resulting in rural economic rebirth. Though livestock husbandry is a viable option for food security, it requires an economic recovery to alleviate poverty and enhance livelihoods in the region.

Planting fast-ripening crops and establishing early warning systems based on the combination of indigenous (experiential) knowledge and meteorological data should all be part of adapting to changing climate trends and variability. The way forward is for vulnerable populations in the region to improve household preparedness in order to plan and manage climate change trends and variability-induced hazards. Because high elevation experiences rarefied air, low or decreased pressure, decreased temperatures, and enhanced insolation, individuals who live in mountain regions should prepare for intensified consequences of climate change on livelihoods. Increased awareness will aid people in mountainous areas in mitigating and adapting to the effects of climate change, reducing the likelihood of more extreme weather. This can be accomplished by promoting conservation agriculture, implementing weather-indexed crop insurance schemes, supporting community-based adaptation, such as providing farmers with climate information, and providing more financial and technical assistance. Climate change impacts on livelihoods in the study region can be mitigated by raising animals that are tolerant of local climatic conditions, establishing fodder banks, providing water, and putting in place early warning systems.

CHAPTER FIVE: CLIMATE CHANGE AND VARIABILITY IMPACTS ON LIVELIHOODS

5.1 Introduction

The results and comments in this chapter reply to the second particular purpose, which is to identify the extent to which climate change and variation have an impact on livelihoods activities in the research region. This chapter consists results on sources of livelihoods, crop production, sale of crops, perceptions on crop yield trends, respondent's perceptions on sustainability of livelihoods options and correlation analysis, followed by discussion andconclusions.

5.1.1 Livelihood sources

From the findings displayed in Figure 5.1, the two (2) main livelihood sources for households were found to be crop production at (n = 150, 37.69%) and economic trees at (n = 123, 30.90%). Other livelihood sources or activities practiced by residents in the study area are farm labour at (n = 56, 14.07%) and livestock rearing at (n = 54, 13.57%) respectively. Communities living in the study area also practice non-farm activities depicted as (n = 15, 3.77%). Non-farm activities can be said to be agri-businesses whereby farm and livestock products are sold to earn an income to supplement the primary sources of income.

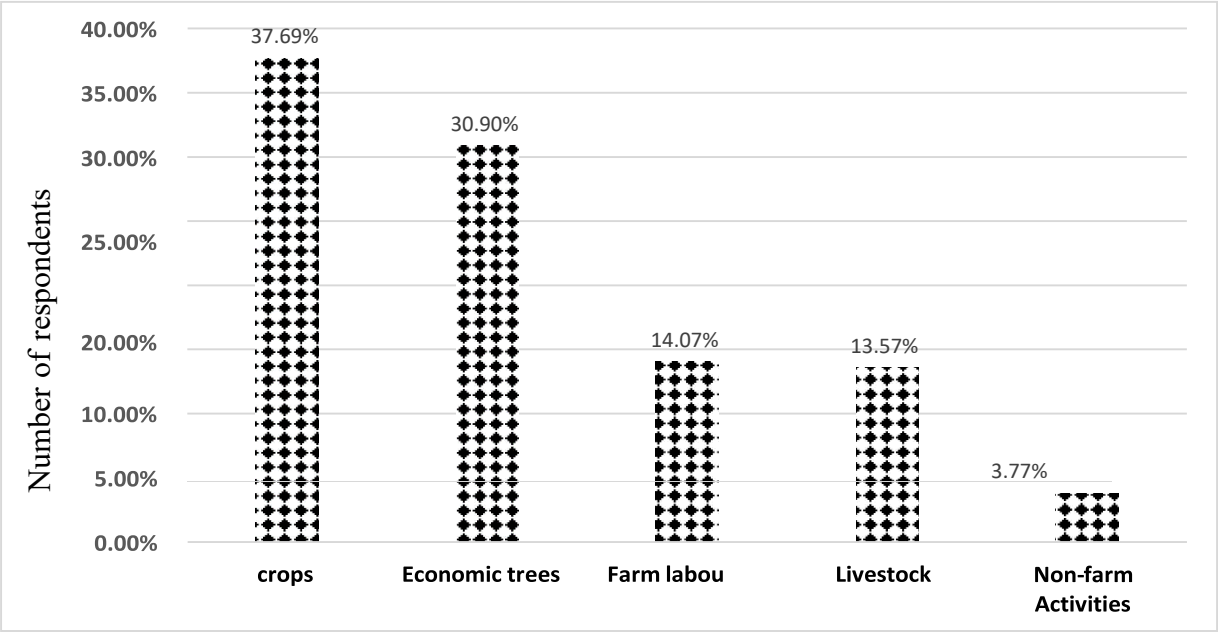


Figure 5.1: Livelihood sources

5.1.2 Crop production

In the study area, the smallholder farmers mostly cultivate maize (n = 352, 34.17%), beans (n = 296, 28.74%) followed by bananas at (n = 107, 10.39%) as seen in the results displayed in Table 5.1. Other forms of crop production include Irish potatoes at (n = 72, 6.99%), onions at (n = 63, 6.12%), leafy vegetables (n = 48, (4.66%) and other at (n = 39, 3.79%). The only cash crop that is grown in the area is coffee at (n = 53, 5.15%). These findings significantly depictthe fact that the stable foods in the region are maize and beans while other crops are sold toearn an income to meet basic household needs.

Table 5.1: Crop production in the study area

Crop production	Frequency	Percentage (%)
Bananas	36	9.05
Beans	112	28.14
Coffee	17	4.27
Irish Potatoes	23	5.78
Maize	132	33.17
Onions	20	5.03
Other	14	3.52
Leafy vegetables	44	11.06
Total	**398**	**100.00**

5.1.3 Sale of crops

As shown in the Table 5.2, a high number of respondents sold farm products for various reasons to meet their basic household requirements. Those households that sold less than half of farm products are represented at (n = 45, 11.31%) and those that sold more than half are represented at (n = 94, 23.62%) respectively. Those households that sold approximately half are represented at (n = 109, 27.39%). However, those who sold virtually everything are (n = 26, 6.53%). On the other hand, those that hardly sold anything are represented at (n = 65, 16.33%) and those that had nothing to sale were found to be (n = 59, 14.82%).

Table 5.2: Sale of crops by households

Sale of crops	Frequency	Percentage (%)
< Than half of farm products	45	11.31
> Than half of farm products	94	23.62
Approximately half of farm products	109	27.39
Everything	26	6.53
Hardly anything	65	16.33
Nothing	59	14.82
Total	**398**	**100.00**

5.1.4 Perceptions on crop yield trends

For the results on perceptions of the crop yields displayed in Figure 5.2, it was established during the study that crop yield had decreased a little at (n = 148, 38.52%) and it decreased a lot (n = 83, 20.83%) depending on the prevailing conditions. The respondents also reported that the yield trends increased a little in crop yields at (n = 111, 27.86%) and increase a lot registered only (n = 7, 1.83%). However, some respondents reiterated that the crop yield trends had remained the same over time (n = 33, 8.59%). A small number of missing responses (n = 9, 2.34%) was also recorded. These changes in the perceptions on crop yields can be attributed to alterations in the environmental conditions and poor farming methods and poor varieties of the seeds that are planted and lack of and or limited use of chemical fertilizers.

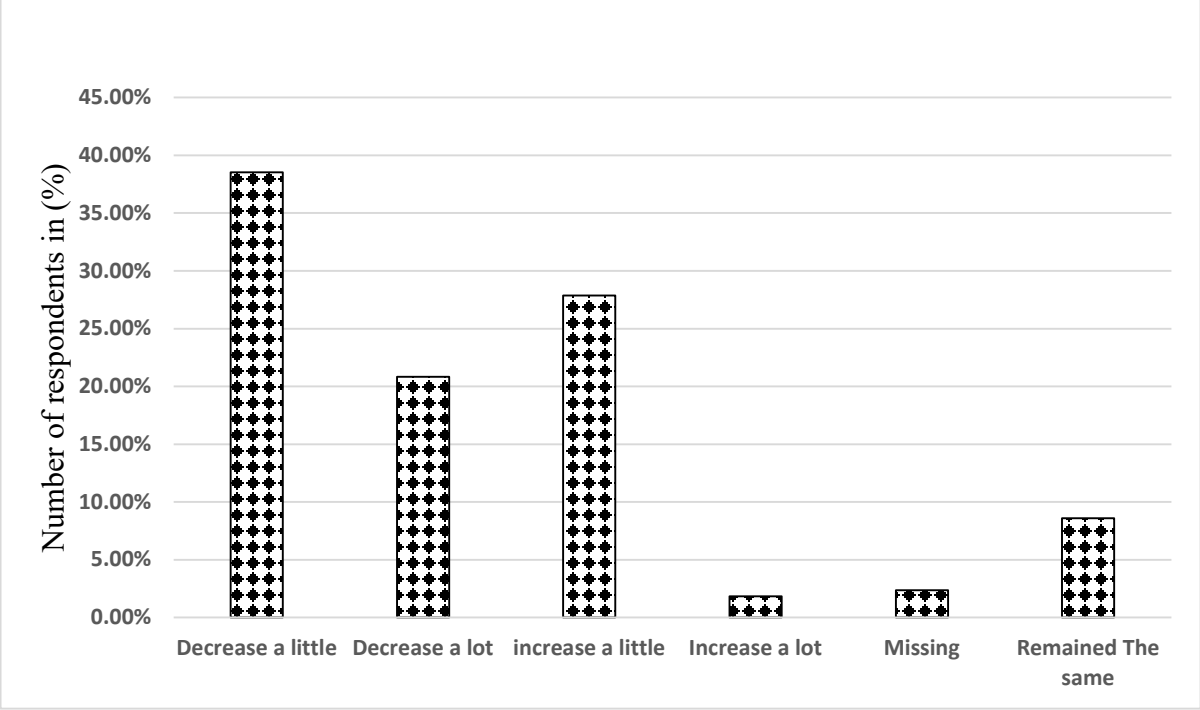


Figure 5.2: Respondents perceptions on crop yield trends

5.1.5: Respondents perceptions on sustainability of choices for livelihoods in the face of climate change

The respondents were questioned about their views on the long-term viability of livelihoods in the research region. They included the head of livestock in the sub-county. Views on livelihoods were also sought from youth representatives during FGDs.

During an interview with the head of livestock production he stated that:

"In 2015 foliage was seriously affected and livestock had little to eat under a changing climate. Changes in the rain patterns accompanied have resulted in the emergence of new tick-borne livestock infections which kill animals. Highly productive livestock species are hardly bred in the region because the residents do not have the knowledge and the skills. Dips have completely collapsed in the region due to poor planning and management. Farmers commonly rear traditional breeds because they are disease, drought resistant and they eat less. Most the animals grazed in the forest are sold before the start of the dry spell, as an adaptive strategy by herders to manage climate shocks and stresses." **Informant interview with Head of Livestock Production Kapsokwony Division on 11th February, 2016.**

(Source: Author 2019)

"Focus Group Discussions (FGDs 2) held with all representatives on 24th June 2016 indicated a decline in agricultural productivity and dwindling livestock production due to diminishing water quantities and decline in pastureland. Impacts of climate change have greatly reduced income at household levels causing unemployment, rising poverty, insecurity, high food prices, waterborne diseases and under-nourishment among children. These issues have been aggravated by climate change and anthropogenic activities which together act as drivers of environmental degradation. Some of the youth fall out of school because of poverty and engaging in early sexual activities." **FGDs 2 conducted for all the representatives in the study area on 24th June, 2016.**

(Source: Author 2019)

5.2 Livelihood options / activities

To achieve sustainable development and improve livelihoods, there is need to develop adaptive capacity and climate resilience in a manner that prioritizes adaptation. In the table 5.3 livelihood options to be achieved by the present study are outlined accordingly.

Table 5.3: Summary of climate change impacts that are likely to impact livelihoods in the study area.

Sector	Impacts of climate change
Crops	• Greater food security will be impacted by extreme climate events on crop production. • Decline in crop yields due to extreme droughts and higher temperatures and increased pests and diseases.
Livestock	• Decline in livestock production due to lack of pasture, reduced access to water and heat stress. • Expected changes in disease patterns and emergence of Tsetse and African Trypanosomiasis in the study area.
Energy	• Decline in forest productivity restricts production of fuel – wood. • Increased demand for energy as population rises in the area.
Economic trees	• These are woodlots which should be planted by every smallholder farm to be sold or for domestic use.
Non – farm activities	• Agri-businesses include the sale of surplus farm products to an income to sustain household livelihoods.
Health and sanitation	• There are incidences of increases of malaria, Rift Valley fever, dysentery, cholera and typhoid.
Forestry	• Removal of fuel wood by locals leads to environmental degradation and reduction of natural resources.
Water resources	• Increased water loss through evaporation from open water surfaces reduces its availability. • Farming along rivers and removal of riparian vegetation leads to water loss especially in the dry season.
Disaster risk management	• Reduce risks of communities from disaster related events such as floods and droughts. • This can be achieved by creating awareness and accessing knowledge on how people can cope and adapt.

5.4 Discussion

According to the conclusions of the study, there is evidence that shifting climatic patterns have had a substantial impact on the livelihoods of the people who live in the study region. Poor households are the most susceptible individuals and groups because they have restricted livelihood options and are confronted with low adaptation capability due to a lack of information and reproductive assets. These groups also face cultural, social and political constraints to access resources and do not take part in informed decisions making. As depicted in Figure 5.1, the three main livelihood sources practiced at household levels were crop production (37.69%), planting of economic trees (30.90%) and livestock rearing (13.57%). Communities through FGDs and KIIs supported by meteorological historical data reported onset of erratic rainfall and rising surface temperatures that are impacting food production. The unreliable, unpredictable rainfall and prolonged drought are responsible for crop failure and limited foliage for livestock. Traditional practices and inadequate land preparations, poor farming methods and limited financial resources for investment stress food production systems thus impacting livelihoods. There is demand for climate change information as reported by a key informant interviewee during research who is also the Head of agricultural production in the region. Rain-fed subsistence agriculture is the main source of income for almost all households. Several coping strategies including farm labour (14.7%) and non-farm income activities are practiced (3.7%). However, non-income activities are rarely practiced due to lack of skills and low education levels. It is also imperative that farmers actions should focus on marketing of the surplus crop produce. Therefore, households should focus on agri-businessesin the case of a surge in production under good climatic conditions. To improve livelihoodsand sustain socio-economic development, a balance must be struck between climate change consequences and agricultural practices.

Most of the livelihood activities (Table 5.1) in the region are dominated by subsistence farming where households grow crops for food and sell the surplus to earn an income. Most people are vulnerable to the effects of climate change because they do not produce enough food. Maize, beans, Irish potatoes, green vegetables, onions, and bananas are among the region's principal food crops. Coffee and tea are commercial crops that are grown and sold to generate income. Some households carry out inter-crop / mixed farming in order to maximize the available land with a focus of producing more yields. Because of sporadic and unpredictable rainfall, rising

temperatures, and inadequate agricultural methods, rural communities in the study area rely on rain-fed agriculture, which is expected to result in a decrease in crop yield. To increase food production, horticultural crops such as tomatoes, onions, and cabbages, as well as green vegetables, are planted. Similarly, as reported in FGDs and KIIs, leafy vegetables and new crop varieties as a measure of diversification in terms of crop failure. Thus, the kind of crops grown depends on the trends and variation in rainfall from season and from year to year as well as variations in temperatures. This is a similar situation in analogous areas such as mountains Kilimanjaro, Kenya, Ruwenzori, Ethiopian highlands and Tibesti Massif mountains in Chad.

As depicted in Table 5.2, a high number of households sold farm products for various reasons but foremost to earn an income to meet other basic household requirements. The crops are sold at the harvesting time at cheap prices and sometimes some households sale everything and remain with nothing to feed on. Such households end up depending on friends, relatives, non-governmental organizations and the government for survival. Some of those households that have nothing to sale might have no land to produce crops. Some households might have land but they lack access to economic empowerment and productive assets due to high poverty levels. Therefore, there is need for a paradigm shift for communities can be empowered to reduce risks/challenges by building resilience and increase adaptive capacity to secure livelihoods as well as reduce poverty. For instance, community's empowerment can be achieved through access of climate information, by putting early warning systems in place, adopting participatory attitude and behavioural change, intensification of agricultural production, increase in cropping diversification, enhancement of marketing policies and natural resource management that is effective. This is a typical analogy in most regions of the world, particularly in tropical mountains where climate change and rising poverty levels are wreaking havoc on livelihoods.

In shown in Figure 5.2, it was established during the study that perceptions on crop yields by respondents had decreased a little at (38.52%) as well as decreased a lot (20.83%) in the past year depending on the prevailing environmental conditions. The change in the perceptions on crop yields can be attributed to alterations in the environmental weather conditions, poorfarming methods and planting of poor varieties of seeds without the use of chemical fertilizers. Communities in the research area have limited access to climate information and resources, which is one of the reasons they are vulnerable to climate change and variable extreme occurrences. Generally, residents are vulnerable to the effects of climate change because of low levels of income, unemployment, low literacy level and poor health and sanitation, low

livelihood resilience poor financial base, starvation and malnutrition among children. For households to effectively respond to low crop yield trends under a changing climate, they must practice modern farming methods by planting improved crop varieties while using chemical fertilizers.

The perceptions by respondents are used to complement alternative livelihoods activities / options such as burning and selling of charcoal, planting and selling of economic trees, petty agri-businesses, casual labourers to boost their overall income to enhance the well-being of the household (Table 5.3). All of these activities were mostly carried out by various homes in the research region. Another coping method used by members of households that are common among the young generation y who relocate to seek greener pastures outside of their homes is to employ humor and better opportunities in terms of employment especially after completion of secondary education. Migration is often carried out the youth from the poor rural households to urban centers within the County and to other Counties where survival options are perceived to be better. These observations are consistent with those of (Mak *et al.,* 2021) he proved that in resource-poor countries, migration is a last-resort livelihood option and a source of revenue for people seeking to better their well-being.

In accordance to the response by the Head of Livestock Production in Kapsokwony Sub-county during the Informant interview on sustainability of livelihoods, it was established that livestock rearing is also a common practice but due to the shrinking pastures, households have tremendously reduced their herds from tens to one or two animals. Some households which own like ten to twenty herds of animals drive them into the forest for watering and foliage / pasture during the months of July to December to fatten and sell them at the end of the season to make a good income as a survival strategy. e. Changes in the rain patterns accompanied by an increase in surface temperatures have resulted in the. Most the animals grazed in the forest are sold before the start December month as an adaptive strategy by herders to manage climate shocks and stresses. Perhaps the best way forward for the smallholder farmer in the region is to adopt Organic Livestock farming in order to boost food security and improve livelihoods. To effectively adapt to climate change, communities in the research area must supplement their depth of indigenous knowledge with scientific technical information that facilitates adaptive decision-making. The goal of this study is to generate demand for information systems and to educate community members about the importance of integrating traditional scientific knowledge into planning. This applies to making informed decisions as when to plant crops

and what quality of animals to be reared to improve the quality of livelihoods. Long- and short-term climate projections are among the data required. It also includes short- and long-term decisions like when to sell cattle and economic trees, as well as what to do with family assets when climate hazards arise. In all these, climate information can play a fundamental role in transforming livelihoods. Long- and short-term climate projections, seasonal forecasts, and early warning of dangers are all examples of information that is required. Climate projectionsfor the long and short term, seasonal forecasts, and early warnings of threats are all examples of knowledge that is needed. The sustainability of livelihoods impacted by climate change can be improved by good planning, efficient management of natural resources and implementation of new adaptive strategies and recommended robust policies. Because they are less aware of measures that increase and promote resilience, poor people in the region are more vulnerable to climate change whims (Leichenko *et al.,* 2014). Climate change's potential implications on economic and poverty traps, as well as adaptation methods and poverty alleviation, must all be considered (Leichenko *et al.,* 2014). Smallholder farmers face the difficult issue of balancing technologies that are beneficial under present climatic conditions with those that may be more adaptable under future climate conditions when selecting traditional technologies. To respond to impacts climate change impacts, integrated scientific and traditional technologies should be applied support adaptation change (Biagini *et al.,* 2014).

A community's initiative to plant trees in the Ruwenzori was hampered by land scarcity and an expanding population, according to a research (KRC, 2012). There isn't enough practical advice on how to improve tropical production's adaptive capacity (Guariguata *et al.,* 2012) as an adaptation strategy. Those that create resilience to climate impacts or shocks and enable adaptation, both those that suggest advanced revolutionary change and those that do not, are the suitable coping adaptive techniques (Biagini *et al.,* 2014). It's also worth noting that if new adaptive technologies aren't fit for the future climate, they can be ineffectual or even dangerous if there isn't enough scientific transformation information (Biagini *et al.,* 2014).

Members of households may eat one meal a day during the months of April, May, June, and July as compared to the usual three meals; they carry out crop diversifications, grow new crop varieties, use chemical fertilizers, carry out mixed farming and crop diversification. The behavioural change is attributed to poor harvest, poor regeneration of pastures for livestock, prolonged droughts and diminishing water resources all which are linked to the change in climate

change. The way forward is to increase local community copying methods in order to promote food security by increasing resilience and adaptive capacities. During focus groupsand key informant interviews, respondents suggested practical methods for farmers in theresearch area. Planting drought-resistant crops that mature quickly, for example, is one of these tactics intensification of agri-business, the smallholder farmer to be advised to plant only certain crops during (MAM) and (OND) and to set up financial institutions to give loans to farmers to improve agricultural productivity. These are innovations that will take care ofvariations in rainfall and temperature trends and variability in the region.

In related studies carried in Eastern Uganda and the Ethiopian highlands, it was demonstrated that the same results of poor crop harvests as indicated in this study were due to unreliable and unpredictable rainfall and increased a frequency of pests and diseases in the region (Guariguata *et al.,* 2012). Poor crop production is mainly due to altered rainfall patterns and reduced soil fertility as per the interview with a farmer in the study area. For example, planting trees can help with environmental and natural resource conservation while also improving livelihoods, but a lack of land in the study region has proven to be a barrier. In a related study in the Ruwenzori highlands, it was discovered that land scarcity and a growing population hampered community efforts to plant trees (KRC, 2012). As an adaptation approach, there isn't enough practical guidance on improving tropical production's adaptive capacity to climate change (Guariguata *et al.,* 2012). Another comparable study conducted by Shemdoe *et al.,* (2009) in Tanzania's Lushoto and Mpwapwa Districts indicated that climate change and variability have an impact on subsistence farmers' food production. Overall, to enhance livelihoods and sustain socioeconomic growth in the study region, multiple complementing actions are required. These measures include intensification of agriculture systems; effective management of natural resources; use of chemical fertilizers to boost crop production; enhancement of marketing policies; control of soil erosion.

5.5 Conclusions

The findings of this study, which were backed up by data from the field and a literature analysis, showed that climate change and variability have an impact on the livelihoods of populations in the study area. As a result of the effects, households have devised a variety of adaptation techniques in order to survive in a changing climate. As a result, there are a variety of technologies and inventions that may be used to adapt to the effects of climate change and fluctuation in the region. For example, smallholder farmers should be advised as when to plant and the type of crop varieties to plant during the long and short rains. Only certain crop varieties can be planted during the long seasons (MAM) rainfall whereas the drought resistant crops should be planted during the short rain (OND) in order to combat climate change. This is an innovation that is bound to take care of long-term rainfall and temperature variations given weather projections in the future. To achieve this innovation, farmers should be given a chance to access climate information for better cropping and livestock production.

Financial institutions should be ready to give loans to farmers for agricultural investments due to unpredictable climate change after they are assured of long-term weather projections. Both the National and County governments can help provide new policies and the way forward to in order to achieve food security. This can help sustain livelihoods through sustainable resource management to enable communities adapt to vagaries of climate change. Adaptive methods based on scientific and indigenous knowledge are critical in the development of adaptivepolicies that will assist residents in the region in adapting to the effects of climate change. Indigenous knowledge, which is founded on years of observations, perceptions, and experiences, can be effectively combined with scientific information to improve climate change mitigation and adaptation measures. Other strategies that should be considered when designing adaptive technologies include cost efficiency, co-benefits, trade-offs and feasibility. New transformational technologies are meant to help enhance resistance to climate change threats while also supporting adaption measures to improve livelihoods. Without adequateunder future climate conditions, new technologies may be ineffective or even detrimental, according to scientific transformation knowledge.

Communities living in the study have changed in behavior due to climate change impacts. Some of the modifications are beneficial to people's livelihoods and should be replicated in other regions. Respondents interviewed during the research (FGDs and KIIs) were in support of the

fact that there exists impacts of the impact of climate change and variability on regional livelihoods. As a result, in order to perform better in the future, communities must increase their coping methods in light of the implications of climate change on livelihoods. This will help communities become more resilient to climate fluctuation and change. Planting traditional / indigenous trees along river beds, water harvesting, soil erosion prevention, cropdiversification, natural resource protection, promotion of sustainable agriculture, putting in place early warning systems, investing in wood-lots, and good natural resource management will all help communities cope with the effects of climate change. Policy makers in collaboration with governments should be compelled to put institutions in place to sensitize communities on the consequences of climate change for people's livelihoods. We therefore recommend further studies to help communities better comprehend how climate change and fluctuation affect people's livelihoods. To access the required information, it is important that communication systems are in place to ensure that women, men, and kids have equal access to information when it comes to communication resources such as radios, television stations, and cell phones. Plausibly, it seems that changes in weather patterns may lead to marked changesin water availability, agriculture, grazing land and natural hazards.

CHAPTER SIX: ADAPTATION STRATEGIES FOR DIFFERENT LIVELIHOOD OPTIONS

6.1 Introduction

The project's third particular goal was to explore household coping and adaptation mechanisms in the face of various climate change consequences in the study area, as well as develop policy suggestions to address future climate change impacts on livelihoods. Hence, this particular chapter contains results of months of food shortage, amount of food bought, modification of household food consumption, perceptions of change in threats (20 years), livelihood diversification, coping strategies, non-farm activities and respondent's adaptation strategies, followed by discussion and conclusions.

6.2 Results

6.2.1 Months of food shortage

A range of strategies have been developed by communities living in the study area in order to adapt to the effects of climate change on food security. In Table 6.1, the months that showed a large number of responses regarding perception months of food shortage were May at (n = 83, 20.85%), June (n = 100, 25.13%) and July (n = 54 13.57%) households. The months with least food shortage in the past one year were January (n = 3, 0.75%), February (n = 9, 2.26%), March (n = 20, 5.03%), September (n = 13, 3.57%), October (n = 2, 0.50%), November (n = 1, 0.25%) and December (n = 2, 0.5%). The results of the third particular aim revealed that food scarcity affects the majority of the poor households in the research area during certain months of the year. The poor are the most vulnerable, and food shortages are common, particularly in the months of May, June, and July. The medium and the well-off households hardly suffer from food short because they may be cushioned by good financial positions.

Table 6.1: Months of food shortage in the past year

Months	Frequency	Percentage (%)
January	3	0.75
February	9	2.26
March	20	5.03
April	64	16.08
May	83	20.85
June	100	25.13
July	54	13.57
August	47	11.81
September	13	3.27
October	2	0.50
November	1	0.25
December	2	0.50
Total	**398**	**100.00**

6.2.2 Amount of food bought

In figure 6.1 respondents gave their opinions on how the amount of food was bought in the past one year by households. It is indicated in the figure that the amount of food bought by most households were: approximately half 53 (39.84%), less than half 90 (23.44%) and more than half 87 (22.66%). The households that bought everything were represented 15 (3.91%) d those that hardly bought anything were 10 (2.60%). The proportion of missing responses was relatively small 10 (2.6%) so it did not affect the interpretation of the findings. Those households indicated nothing were 19 (4.95%) Such households might be very vulnerable with hardly any land to till to produce food for consumption or might be deeply entrenched in poverty so they have no money to buy food or have no land to produce food.

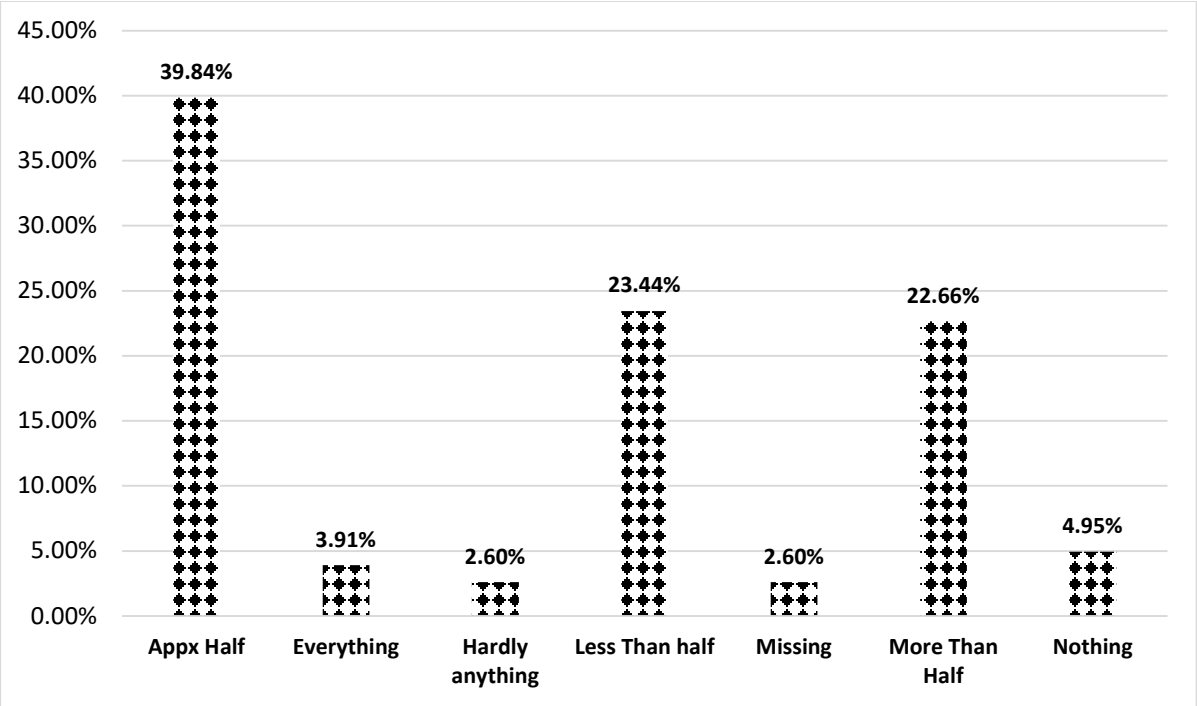


Figure 6.1: Amount of food bought

6.2.3 Modification of household food consumption

Climate change and variability have an impact on the types of food consumed by the majority of the households in the study area. Figure 6.2 demonstrates the modification of household food consumption in the study area during the times of food shortage. This is strategy that was designed to help the survival of the individual family members. The number of households that ate less of meals per day were (n = 150, 39.06%) and the households that limited the sizes of the portion were (n = 65, 16.93%) respectively. Similarly, the households that resorted to limit food portion sizes were (n = 61, 15.89%) whereas some households settled on eating cheaper meals per day (n = 50, 13.02%). Modification of household food consumption by having less people at home during meal times was indicated by (n = 40, 10.42%) respondents. Some other households were represented by missing (n = 15, 4.69%) responses depicting that such households would have nobody at home to eat during meal times. All these measures are designed by mainly the poor households as survival strategies. However, they vary from one household to another depending on the number of members of a household or complementary source of income. Limit means to restrict whereas to reduce means bring down the size of the portion or quantinty or portion of food.

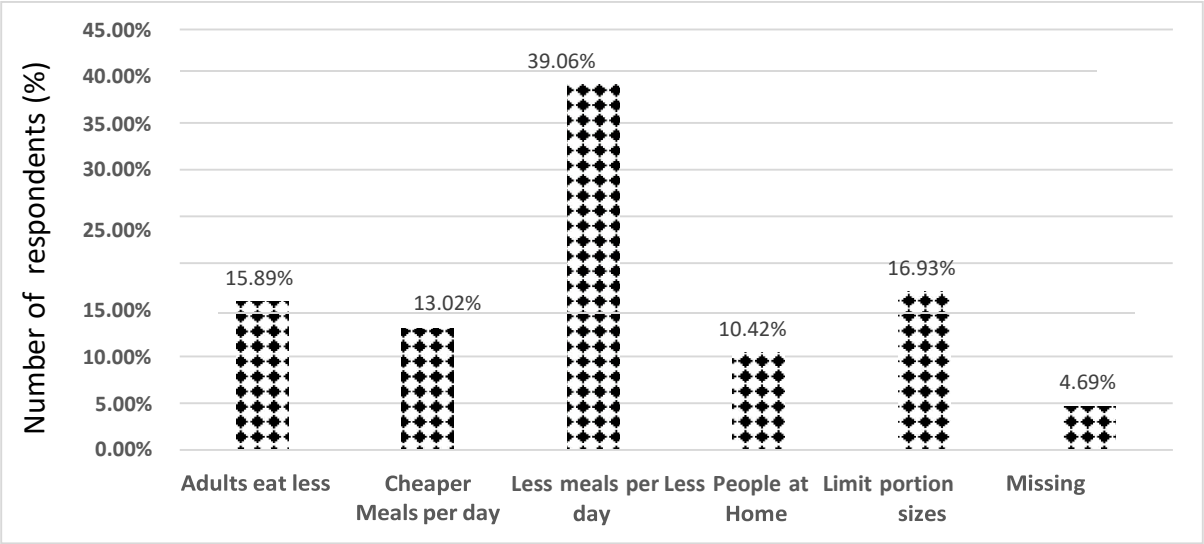


Figure 6.2: Modification of food consumption by respondents during food shortage

6.2.4 Perceptions of threat shift (20 years)

Perceptions of change in threats for the past 20 years are demonstrated in Figure 6.3. The respondents who reported that the threats were no less than before stood at (n = 103, 26.82%) while those who were missing completely were (n = 14, 3.65%) respectively. Similarly, respondents who answered that the threats were about the same in 20 years were (n = 91, 23.70%) and those who said that threats are a lot constituted (n = 79, 20.57%). However, those who responded that threats did not exist at all in the last 20 years constituted (n = 0, 9.11%). Another set of respondents said that threats had occurred in the recent 20 years, but that theyhad been minor (n = 62, 16.15 percent). As demonstrated by the chart, the cumulative totals of threats were perceived to be (n = 194, 50.52%) depicted the fact that in the last 20 years, the majority of respondents in the research area had seen climate change and variability as risks. However, the proportion of missing responses was relatively small (n = 14, 3.65%) so it didnot affect the interpretation of the findings.

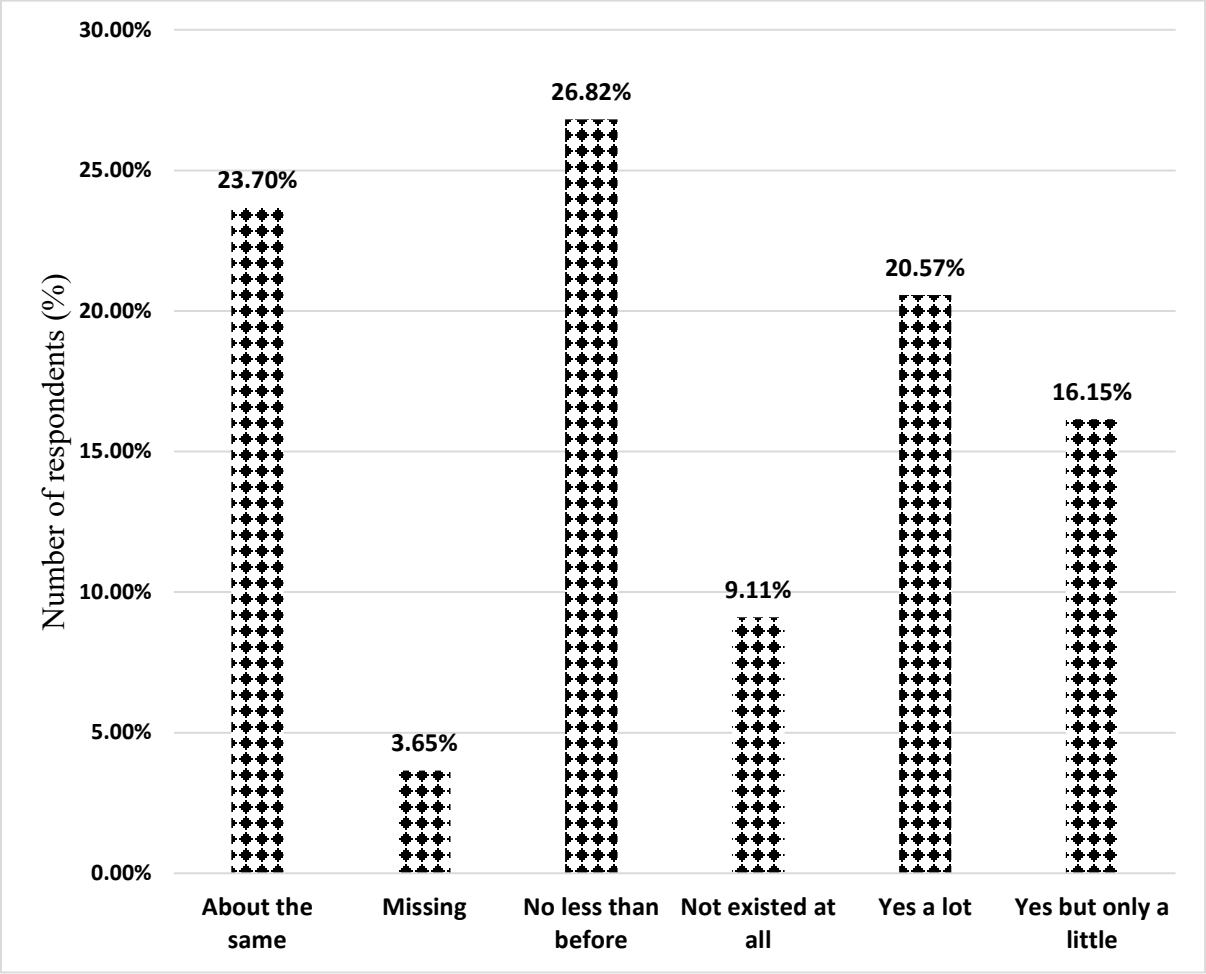


Figure 6.3: Perceptions of respondents to changes in climate threats

6.2.5 Livelihood diversification

As displayed in Figure 6.3, livelihood diversification in the research area as a means of mitigating the effects of climate change and variability was not an option by most of the households that participated in the survey. A huge majority of the respondents (n = 260, 60.15%) did not diversify their livelihood options whereas the remaining (n = 138, 32.81%) participants diversified by engaging in new non-farm activities. A minimum number diversified to the existing non-farm activities (n = 3, 3.78%) while more members were involved non-farm activities (n = 2, 3.26%). To be able to diversify, capital resource is required and yet most are poor households which are very vulnerable to climate vagaries. This might have been for the fact that they owned some land and input to invest.

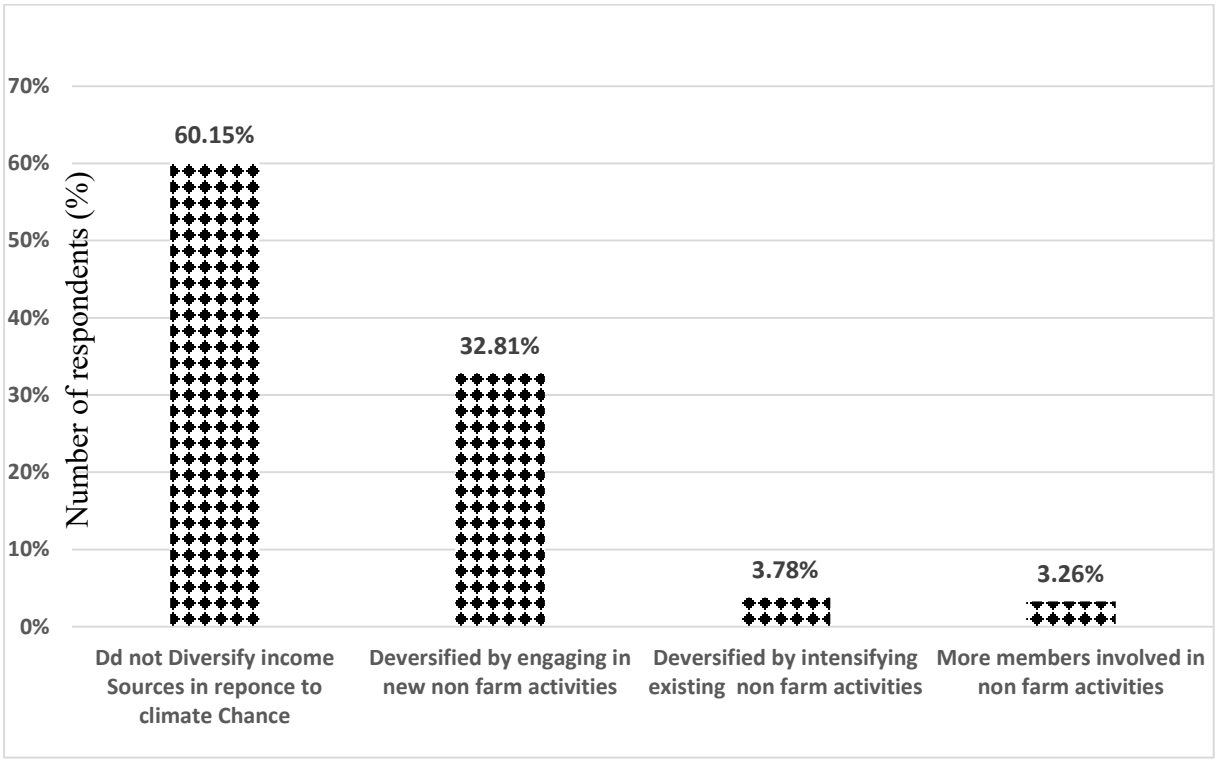


Figure 6.4: Livelihood diversification

6.2.6 Coping strategies

As summarized in Table 6.2, household coping mechanisms had a limited number of missing cases (n = 10, 2.51%) which did not influence interpretations of the results. Those respondents who purportedly received help from organizations constituted (n = 97, 24.37%) whereas respondents who received help from other people constituted (n = 85, 21.36%) respectively. Other options that had an appreciable number of responses were sale of property (n = 42, 10.55%), spend less on food (n = 47, 11.81%). Some respondents opted to migrate to new areas (n = 22, 5.53%) as a coping strategy. Similarly, some respondents opted to be engaged in agri-businesses to earn extra income (n = 75, 18.85%) to sustain their livelihoods. Another strategy depicted by respondents was to reduce expenses (n = 20, 5.03%) as a coping measure. Those respondents who were missing (n = 10, 2.51%) might have had no coping strategy to adopt. Overall, it can be summed up that most of the households had coping strategies that would be applied for sustenance.

Table 6.2: Coping strategies adopted by households

Row Labels	Frequency	Percentage (%)
Earn extra income	75	18.84
Help from organizations	97	24.37
Help from people	85	21.36
Migration	22	5.53
Missing	10	2.51
Reduced expenses	20	5.03
Sale of property	42	10.55
Spend less on food	47	11.81
Total	**398**	**100.00**

6.2.7 Non-farm income activities

Many individuals engage in non-farm occupations in addition to agricultural production and livestock rearing, as seen in Table 6.3. From the research study it is clear that the three main non-farm income activities carried by smallholder farmers were blue collar work (n = 121, 30.40%), petty trade (n = 108, 25.88%) and white-collar work (n = 103, 25.88%) making a cumulative total of (n = 332, 83.42%). The number of missing responses could not significantlyaffect the interpretations since they are less than 5% i.e. (n = 9, 2.26%) respondents.

Table 6.3: Non-farm income activities

Non-farm income activities	Frequency	Percentage (%)
Blue collar work	121	30.40
Missing	09	2.26
Other non-farm self-employment	57	14.32
Petty trade	108	27.14
White collar work	103	25.88
Total	**398**	**100.00**

6.2.8 Respondent's adaptation strategies

An interview with a window in the study area revealed that**:**

> *"I am a poor widow who lacks money to buy land elsewhere. The lady migrated out of Chepyuk Settlement Scheme after her husband was murdered in cold blood by arsonists during the famous land skirmishes of 2007 and now lives in Kapsokwony Township. The migration is attributed to the fact that land in the region has become scarce due to exponentialpopulation increase. As at now she stares poverty in her eyes and she has nobody to look upto. Her family members can manage only one meal a day since she moves from house to house looking for house chores on a daily basis which to earn her livelihood and that of her children.*" **In-depth interview with a widow on 7th February, 2016.**

(Source: Author, 2019)

Similarly, the medical doctor in charge of the District Hospital observed that:

> *"I believe climate change is real and its extreme events are responsible for threats to livelihoods among households. Area residents lack clean drinking water and proper sanitation especially during rainy periods. During enhanced climate events, waterborne diseases become rampant because of increased water pollution. Chemical fertilizers carried downstream from open fields end up in river water thereby cause water pollution resulted in diseases such a disease called leptospirosis, dysentery, giardiasis, typhoid, cholera and intestinal fever and malaria.*" **Informant interview with the District Medical Officer, Mt. Elgon Sub-District Hospital on 10th February 2015.**

(Source: Author, 2019)

Interview with a resident of Namorio sub-location was summarized as follows:

(Source: Author, 2019)

"Climate change is being experienced in the region as indicated by a rise in temperatures and rainfall patterns which have become more erratic, unreliable and unpredictable. Crops now mature faster than ever before. However, area residents continue to enjoy ecosystem services with impunity. The area experiences low food production and people are poor because of low incomes. Most of the maize (70%) is grown in the forest and only (30%) is grown in the villages. They do not plant certified seeds to give expected yields at harvest time. Very few people plant economic trees because of poor financial base." **In-depth interview with a resident of Nomorio sub-location on 15th February, 2016.**

We conducted an in-depth interview with a young man from the Kibuk Sub-location, who stated:

"The main problem with the effects of climate change threats to livelihoods in Kapsokwony Division is lack of money, adaptive knowledge and skills. Some are embroiled in boda boda (i.e.) motor bikes used as transport means) business, while some are engaged in video and cyber business so they can put something on the table at the end of the day. Some have gone into self-employment especially in the horticultural farming where they are trying a hand to raise market-oriented products that include green kales, potatoes, tomatoes, onions and carrots. To alleviate poverty, the youth are should be trained so they acquire new knowledge and skills to help adapt to livelihood challenge. The youth also to join Community Driven Development Committees (CDDCs) where they are trained to make budgets, keep records, make informed decisions andon achieving set targets." **In-depth with an interview with a resident of Kibuk sub-location on 27th February, 2016.**

(Source: Author, 2019)

6.3 Discussion

The results of this research indicate the majority of impoverished households in the study area are food insecure because either they have a poor financial base to buy food or have no land to till to produce enough food. The months with most food shortage in the past one year were April, May, June and July. The poor households were the most vulnerable during these months as they were faced with food insecurity. A range of adaptation strategies were developed by poor

households to counter months of food shortage (Table 6.1). These strategies practiced by households to counter food insecurity include: purchase of food from outside sources; seek help from relatives and friends as well the County and National Governments. Others work as casual labourers to earn some money to buy food and even so some sell household assets to counter food shortage. The medium and the well-off households hardly suffer from foodshortage because they were cushioned by good financial base or they own large tracts of land of approximately ten to twenty acres which they till to produce enough food.

The findings on the amount food purchased demonstrate that most households bought food due to the shortage experienced in the past one year (Figure 6.1). Some of the households bought approximately half of their food requirements (39.84%), while other households bought less than half (23.44%) while about (22.66%) of the household bought more than half of their food requirements. Those households that bought approximately everything were (3.91%) and some hardly bought anything (2.60%) in the past one year. The poor households bought every food item that was consumed by members of the households because such households are deeply entrenched in poverty and hence, they have no money to buy food or had no land to produce food. Hence, a range of adaptive strategies had been taken by residents in the study region to combat the effects of climate change on food scarcity. Several complementary adaptive measures can be put in place to improve on food insecurity as well as to reduce the amount of food bought by households. Firstly, members of poor household's cash for work, credit, crop and livestock insurance, and better food security are all needed social protection programmes. Second, to strengthen adaptive ability, better and enhanced governance of fundamental services such as cooperatives, a decent education, and good health. Finally, they must maintain control over production assets like forests, energy supplies, and water resources in order to mitigate climate change impacts.

Figure 6.2 depicts changes in household food consumption during times of food scarcity: in the previous twenty (20) years, adults in impoverished homes have eaten fewer (15.39 percent) or cheaper (15.02 percent) meals per day. Within households' members resorted to eat less meals per day (39.06%) whereas in some others households it was resolved that fewer peoplebe at home (10.42%). Some households resorted to limiting food portions /sizes while others did not have any food to eat according to missing responses (4.69%) as depicted in the chart. These are designed survival strategies by various households in the region as a modification of less food production mainly due climate change and variability. This discussion shows that the

modification of food consumption strategies by households in the region is directly related to poverty levels whereby the well-off households hardly modify their food consumption since they have better financial basis to cushion themselves. The analysis also revealed that the wellbeing of households depends on the distribution and quality of land owned by households. Households with greater land are capable of producing food, whereas poor households have limited land and financial resources for food production. Poor households reported to FGDs and KIIs that they lack financial resources due to a lack of collateral, putting them at a higher risk of crop failure and livelihood stress than well-off households. Moreover, households witha decent education and sound financial assets had a better livelihood option to diversify their income resources than the poor households which are faced with marginalization and poverty. The way forward is to strengthen local community's copying strategies to enhance resilience, adaptive capacity to improve food security; planting of drought resistant crops that take a short time to mature; intensification of agri-business and the setting up of financial institutions to give loans to farmers to improve agricultural productivity. Planting of grass, indigenous trees will improve degraded water resources thereby restore livelihoods. These are innovations that will take care of variations in rainfall and temperature trends in the region to sustain livelihoods and enhance socio-economic development.

Figure 6.3 shows how respondents' opinions of climate hazards were affecting livelihoods in the area. When asked if they had noticed any changes in threats over the last two decades, some said they had not noticed any; others said the dangers were the same as before. others said threats were about the same in previous years; while still others said threats had increased significantly in the last twenty (20) years than before. Others stated that climate threats do not exist, while another group of respondents saw only a minor harm to their livelihoods. Climate change and variability in the region were viewed as threats by most respondents, but they were unable to state so because they did not understand whether these environmental changes amounted to climate change. Communities in the area have varied approaches to increasing adaptive capacity and resilience, according to the current study. To effectively respond to climate threats on livelihoods, communities face the challenge of harmonizing science and traditional technologies that are both advantageous in the current climate to combat impacts of climate change on livelihoods. While current climate technologies can help increase resilience to shocks and enable adaptation, they are frequently incremental rather than transformative (Biagini *et al.,* 2014). If technologies are not adequately matched with future climate circumstances, they can be useless

or even detrimental if there is insufficient scientific knowledge of future conditions (Biagini *et al.,* 2014).

Diversification of livelihoods is a strategy for mitigating the effects of climate change in the studied region. However, a large majority of the respondents did not diversify for reason or the other while others diversified. Some households diversified by engaging in new non-farm activities whereas others diversified intensifying non-farm activities (Figure 6.4). Capital resource base and access to information can be very big impediments to achieve diversification in order to resist climate change calamities, particularly for low-income families. Communities in the research region have limited access to knowledge and resources, which is one of the reasons they are subjected to extreme climate change and variability occurrences. Smallholder farmers' tolerance to extreme weather events and climate change is enhanced through crop diversification. Some of the results from the study show that livelihood diversification was not done by most of the households that participated in the survey. A huge majority of the respondents (60.15%) did not diversify whereas the remaining did so. The majority of respondents agreed that they diversified (32.81%) by engaging in new non-farm activities. A reasonable number of those who diversified by engaged in new non-farm activities.

Households adopted a variety of coping techniques to deal with the effects of climate change and variability on their livelihoods. Local people in the research area have also created several coping methods to combat the effects of climate change and variability on livelihoods, according to the findings. There were a number of missing cases in the home coping mechanisms while households that received help from organizations represented a significant number. Some households received help from other people and others sold property as a coping strategy. Members of some households engaged in agri-businesses while members of other households did not engage in any coping strategy to survive (Table 6.2). Such measures includepurchase of food, engaging in new non-farm activities, planting of economic trees, crop diversification, reduced household expenses, spending less on food, destocking, modification of food consumption and getting help from other people. For example, smallholder farmers who live adjacent to the forest drive their animals into forest for pasture and watering and buy hay from neighbouring Trans Nzoia County to complement the animal feeds especially during the drought periods when pasture is scarce. Adaptive coping techniques that increase resistance to climate change shocks and support adaptive strategies, as well as incremental progress and

transformative change, are appropriate (Biagini *et al.,* 2014).

To supplement household income from the sale of farm products, residents in the study region must engage in non-farm revenue activities. Some of the non-farm activities include blue collar jobs, petty trade and white-collar jobs (Table 6.3). Under a changing climate, theimplementation of Climate Smart Agriculture (CSA) remains a viable alternative for achieving food security and socio-economic development in the region, as well as improving livelihoods. The smallholder farmers should feature CSA as a solution to resolving many livelihood challenges and make modern agriculture development a priority. The household membersshould acquire new skills and a decent education in order that they can engage effectively inthe non-farm activities. Smallholder farmers need to choose, use, and capitalize to enhance their livelihoods and well-being through adaption technologies by use of new adaptation technologies to improve their livelihoods under a changing climate. Adoption of new robust policy recommendations and adaptive strategies to enhance capacity building, sustain livelihoods and improve the standards of living for the area resident.

Participatory dialogue by respondents during interviews with FGDs and KIIs brought forth successful adaptation strategies which should be implemented to households' means of subsistence and reduce vulnerabilities. Communities can work together to reduce home vulnerability by engaging in activities such as disaster risk reduction, mitigating climate change consequences, good environmental management, and poverty reduction. Despite the fact that the current adaption techniques in the examined area are good and resilient, socio-economic factors such as population expansion and related dynamics may modify them. For example, an upsurge in human population will lead to the fragmentation of farm land into small portions that cannot be used for agricultural production by households. Exponential population growth will definitely stress water resources at household levels. In future water scarcity will stress food production, trigger several new diseases, worsen fuel shortages and retard socio-economic development thus impact livelihoods. Unreliable rainfall patterns and an increase in surface temperatures will play a big role over water resources crisis. New adaptive measures to be provided by this study need to be factored into livelihood activities to lessen the vulnerabilities of the communities. For example, a community's initiative to plant trees in the Ruwenzori was hampered by land scarcity and an expanding population, according to the study (KRC, 2012). Sustainable forest management is an effective way to improve a forest's ability to adapt to climate change (Guariguata *et al.,* 2012). There is need to adapt existing practices in order to lessen

livelihood susceptibility to climate change impacts (Guariguata *et al.,* 2012).

Adaptive capacity, which comprises adjustments in both attitude and behaviour change, is a vital factor in the improvement of livelihoods and socio-economic features of communities and households. Under the current climate change conditions, it is critical to select appropriate and helpful technologies as adaptation techniques, as well as those that can be used in the future. The traditional and modern technologies used by smallholder farmers in the study area reduce vulnerability of the households and improves agricultural productivity. Erratic rainfall, rising temperatures, soil erosion and soil exhaustion, poor farming methods, exponential population growth and deforestation will impact farmers who depend on agriculture and livestock systems especially those with low income hindering them in making intensive investments. In support, literature on livelihoods have low income, a large proportion of income spent on food, and reliance on rain-fed agriculture are all variables that make people vulnerable to climate stresses, according to the paper (Ellis, 2000; Ellis and Mdoe, 2003; Ellis and Allison, 2004; Scoones, 1998).

During focus group discussions (FGDs) and key informant interviews (KIIs), participants acknowledged the importance of information distribution as a foundation for building household capacity and resilience. During a lengthy chat with a young person, he stated: *"To alleviate poverty, the youth should be trained so they acquire information, new knowledge and skills to help adapt to livelihood challenges. The emphasised the need of youth involvement in Community Driven Development Committees (CDDCs) where they could be trained to make budgets, keep records, make informed decisions and on achieving set targets."* Households must engage in educated adaptive decision-making through discourse and innovative adaptation measures to lower their vulnerability to climatic vagaries in order to effectively respond to these livelihood problems.

In the region, there is now very little or no training in climate change and adaptation, as well as food security, resulting in inadequate workforce structures in these fields. Focused climate change and adaptation training must be implemented to accelerate workforce growth in order to increase food productivity and improve livelihoods, particularly in African ecosystems. Because the poor are projected to be particularly vulnerable to these consequences in the study region, the community will have access to extensive information on the impacts of climate change on livelihoods as a result of this research. However, little is known about the variables

that help people be more resilient and adaptable. More research into the traits and conditions that enable disadvantaged communities and individuals to respond, recover, and move forward in the face of climate stress and catastrophic occurrences is needed.

6.4 Conclusions

The major activities during this particular study were achieved through integration of knowledge by experts and local community members. The community members with the assistance of the individual experts in collaboration with other institutions were allowed to synthesize the new transformation knowledge and products of the research findings. This was done through dialogue and collaboration during focus group talks, informant and in-depth interviews, and household questionnaire administration, validation of the findings was carried out so dissemination and assimilation processes of the product could be achieved. Other strategies that should were considered when designing adaptive technologies. They included cost efficiency, co-benefits, trade-offs and feasibility. Sometimes vulnerabilities of a community may result from differences in traditions, culture, socio-economy, lifestyles and gender differentiated responses. The technology that must be adapted must be beneficial under current and future climate circumstances. Technologies are supposed to household resilienceto climate change impacts should be improved, and adaptation options should be supported. Technologies can be ineffective or even destructive if there is insufficient scientific knowledge about future conditions.

The observations made during the study revealed that coping and adaptation strategies used against climatic stressors are rooted in the indigenous knowledge systems (FGDs and KIIs). Over the years, traditional indigenous knowledge has incorporated components of preparedness for dealing with natural calamities. Communities living in the region have evolved their knowledge on climate variations, believes, skills and experiences that have helped them in the prediction of natural and human based disasters but have also devised coping techniques to deal with climate threats. Observations gathered during the investigation revealed that individuals in the area planned for a variety of livelihood threatsin each home.

Research findings had the following implications: Foremost, annual and seasonal rainfall and temperature patterns and variability may have a severe impact on crop and livestock output, with total crop failure occurring in extreme circumstances and lengthy droughts, while large floods sweep away the crop. Secondly, farmers would make different farming decisions if they

were aware of changing trends in yearly and seasonal rainfall. Thirdly, residents must diversify cropping systems, integrate traditional and scientific technology, embrace Climate Smart Agriculture (CSA) to attain food security, and put in place efficient and effective early warning system structures to adapt to climate change and variability.

CHAPTER SEVEN: SYNTHESIS, GENERAL CONCLUSIONS AND RECOMMENDATIONS

7.1 General information

This chapter of the whole theses discusses the key discoveries and outcomes from chapters four (4), five (5), and six (6). The primary objective of the study was to evaluate the long-term impacts of climate change on rural households in the Kapsokwony Division of the Mt. Elgon Sub-county. The particular goals were: The first particular goal was to analyze historical climate data for trends, variability, and villagers' views; to assess how much climate variability and change affect options for and activities related to livelihood in the research region; as well as to look at the coping and adaption strategies used by households in response to diverse consequences of climate change and variability. Additionally, they provide policy advice forthe control of future implications of climate change on livelihoods. The chapter also reflectsthe relationships between specific objectives 1 and 2, 1 and 3, and 2 and 3 in order to achieve the main target of the study. In order to increase resilience and adaptive capacity to sustain socioeconomic development and improve livelihoods, general conclusions and policyrecommendations were made based on the study's findings. These were discussed at the end of the chapter.

The primary objective of the study was to assess the long-term viability of livelihoods impacted by climate variability and change in the study area, and this synthesis connects to thatobjective and places it within the conceptual framework (see section 3.3). Prior to anythingelse, the study examined historical climate data to look for patterns, variability, and villagers' views of the climate as well as how climate change affects livelihoods in the study area. Rainfall and temperature trends are essential components of climate regimes because they havean effect on agricultural systems and livestock production, which in turn affects the way of life for locals. In order to ascertain the potential impacts of climate change on people's lives, climatic information was provided by the study of climate change data sets. Based on this research, long-term policy recommendations were developed to enhance livelihoods and support socioeconomic growth. Unreliable, unpredictable, and diverse rainfall patterns are justa few of the effects of climate change in the study area. These markers of climate change are also present. in addition to a rise in temperature trends that have been rising from 1986 to 2015.The results showed that the area's seasonal and yearly rainfall distribution

ranged from uniform to moderate, along with rising temperatures. Weather-related information matched community views about climate change and variability.

Additionally, the results of the analysis of climate data showed that households' livelihoods were being impacted by climate change, as shown by rising poverty rates, increased food insecurity, decreased crop productivity, degraded water resources, and declining livestock production. Since humanity depends on the abundance of natural resources available on the surface of the globe, rainfall and temperature regimes are essential to life. Because of the shifting weather patterns, the communities residing in the study region are vulnerable. For instance, a rise in the seasonal variability of rainfall influences how farming groups make decisions about when to prepare the ground, when to plant, what kind of seed to plant, and what to do when risks occur. Intensified land misuse, such as improper farming methods, excessive grazing, deforestation, deterioration of water resources, and land pollution, might threaten agricultural productivity. Planning properly and managing natural resources (water supplies, forest cover, and soils) are essential for maximizing the profits from agricultural techniques. This means that the land should be managed better to provide long-term socio-economic and socio- ecological functions while also making the best use of it possible to suit evolving human requirements (such as those related to agriculture, forestry, and conversation).

The study revealed that the livelihoods of the populations in the study region were significantlyimpacted by climate change and fluctuation. According to available options for subsistence andclimate data based on how climate influences affect subsistence options, there are noticeable adaptation variances among the local groups. To address the myriad threats that climate changeand climate variability pose to family livelihood systems, it is desirable to integrate and synthesize knowledge from a wide range of stakeholders. The resilience pathway is seen as a process rather than as a system's static state. Utilizing their adaptability, households andcommunities should develop a resilience strategy. This is so that members of resilient communities may obtain information and participate in decisions that affect their quality of life. This project's main goal is to gain a better understanding of how climate change affects rural lives in the study region. It also helps us comprehend how susceptible populations are to climate fluctuation and change. The study blends long- and short-term adaptive measures with community-specific coping mechanisms to maintain

development and enhance livelihoods. Numerous studies have shown the value of adaptation techniques that rural residents could employ to deal with the effects of climate change (Adger, 2003; Hulme and Shepherd, 2003; IPCC, 2001b).

The research region's communities' capacity to adapt to future climate change is currently poorly understood. For instance, one crucial tactic in boosting resilience is the diversification of livelihoods affected by climate change. But for it to be successful, it needs to be done in a knowledgeable and empowered way. The decision to diversify is always pushed by recurrent climate shocks and pressures on established livelihood options. The decision to diversify is always pushed by recurrent climate shocks and pressures on established livelihood options. A person's choices for obtaining food and income become available when one method of doing so fails. Traditional methods and practices for making a living in the study area's households are being called into question as the effects of climate change become more obvious. Communities in the study region should augment their extensive indigenous knowledge with current scientific andtechnical knowledge that enables all stakeholders to make informed adaptation decisions. Similar to this, families with more financial resources and education have more options for income diversification. Because those with more resources and capacities are less sensitive to the effects of climate change, the underlying causes of poverty and marginalization are intimately related to those effects (Adger, 2006; Ellis, 2000; Smit and Wendel, 2006).

As a result, it's critical to sustain and enhance current adaptive capacity while combining scientific technology, new transformation knowledge, and unique concepts and methodologies to adjust to shifting circumstances in the face of mounting risks to livelihoods posed by climate change. This method will assist people in resolving issues by altering their perceptions and behavior, boosting resilience, building adaptive ability, disseminating information about climate change, and protecting natural resources. Additionally, it assisted in the providing of scientific evidence to aid in the formulation of long-term strategies and policies to maintain the socioeconomic growth of the region and enhance the quality of life for its residents. Action knowledge from other disciplines was intended to be developed from the outset of this particular project to aid in the fight against climate change and enhance livelihoods. Along with gaining new transformational information, participants in the interviews and concentrated group discussions also developed their adaptive capacity and resilience. In order to support informed decision-making in the face of climate change and

enhance livelihoods, the indigenous community's experiential knowledge—based on observations, perceptions, and experiences throughout time—was merged with scientific technical information (non-experiential). As a worldwide issue, climate change has compelled governments, scientists, and policymakers to put in extra effort to mitigate or adapt to it (IPCC, 2013; GoK, 2010).

Climate change effects on livelihoods by synthesizing and integrating knowledge from all disciplines (Thalheimer *et al.,* 2021). In order to capture the effects of weather and climate-related events on livelihoods, it is crucial to increase the incorporation of climate data in future studies on climate change (Thalheimer *et al.,* 2021). Based on the opinions of questionnaire respondents (section 4 of the questionnaires), FGDs, and KIIs, policy interventions were suggested because it was determined that the households' current coping mechanisms and traditional technologies were insufficient. By boosting resilience and adaptable ability, the long-and short-term adaptation strategies and policy recommendations created by all researchers from academia and traditional communities during the research will be used to improve livelihoods.

The following conclusions are drawn from the analysis of climate data: Agriculture and animal production are significantly impacted by significant trends and variability in rainfall, with total crop failure occurring under extreme conditions owing to protracted droughts or when floods sweep away the crop. An increase in annual rainfall volume, a decline in MAM rains, and an increase in the OND rainfall pattern all have a significant impact on farmers' informed farming decisions. Crops that ripen quickly should be planted, and early warning systems built using a combination of local knowledge (experiential knowledge) and meteorological data should also be implemented. Enhancing institutional preparation in advance of climate change trends and variability-induced threats to the region's most vulnerable communities is the recommended course of action. To enhance livelihoods, the National and County governments should supervise farmers' use of both traditional and contemporary technologies in agricultural practices.

Farmers can plant maize before the start of the rainy season in this era of climate change, relying on generational expertise and traditional techniques, but yet have a poor harvest because of factors beyond their control, such as crop-killing bugs, but most crucially, climate change (Schmidt 2019). Mobile telephony in Africa has developed since its

inception in the 1990s, reflecting various technological advancements. These developments have made it easier than ever before to get climate information because of the importance that mobile devices play in daily life. African improvements in mobile telephony infrastructure configurations have made people think about how mobile devices are used in daily life (Guma *et al.,* 2021). Therefore, relevant and solid policy recommendations were created and validated in order to enhance livelihoods and promote sustained socio-economic development. The government and stakeholders must take the lead in funding, in providing the essential knowledge, abilities, and technology, and in reporting on the adaptation activities in order to carry out the action plan. The cross-cutting initiatives include providing climate information, building capacity and enhancing resilience, and developing long-term policy recommendations to improve livelihoods and the promotion of socio-economic growth.

7.2 Conclusions

The volume and distribution of yearly and seasonal rainfall varied significantly, according to the study. This was related to an increase in annual rainfall extremes, such as high-intensity rainfall and droughts, which influenced rainfall patterns and variability. Climate change, changes in altitude, inadequate farming methods, and other factors can all contribute to significant rainfall variations. Communities' perception of rainfall adequacy was in line with observational data, where respondents acknowledged late rainfall onset, mid-season droughts and early cessations of flash floods, mudslides, landslides, and lengthy droughts are all climate-related disasters. were reported to be on the increase. Similar studies conducted in mountain regions of the world are in agreement with the findings of this study, which show that rainfall patterns and variability are increasing.

Trend analysis of temperature data found out that the region has experienced significant temperature rise in the past three decades. Evaporation increases when air temperatures rise, contributing to dry conditions, especially when precipitation falls. Even if total annual precipitation does not decline, precipitation in many parts of the country is expected to become less frequent. Drought is projected to become more prevalent in some areas, affecting food production and livestock production. According to studies by Olaka *et al.,* 2019 in the Lake Basin on projected Climatic and Hydrologic Changes to Lake Victoria Basin Rivers under Three Representative Concentration Pathway (RCP) Emission Scenarios for 2015 - 2100 and Impacts on the Water Sector, the OND (October,

November, and December) season receives more rainfall than the MAM (March, April, and May) season under higher emission scenarios. This is likely to impact negatively on the water resource sector resulting in food insecurity and thus livelihoods.

The communities living in the study area were investigated from the perspective of a people who experienced livelihood threats due to climate change. The households represented in this study are those who are experiencing increasingly frequent and severe livelihood consequences. Climate-related stressors are compounded by a slew of structural weaknesses, including high poverty, fast population expansion, increased strain on natural resources, limited livelihood possibilities, and low educational attainment. The high rates of poverty and low educational attainment are intertwined with impacts of climate change on livelihoods. Significant changes in the frequency and severity of climate events, as well as their implications on crop systems, livestock raising, food security, vulnerability, and health, were reported by participants in the household questionnaire survey, focus groups, and KII interviews.

Climate change and variability have an impact on livelihoods in the research region, according to the study. There was evidence of traditional knowledge and informed decision making that were essential in the sustenance of livelihoods. Further, there was also the evidence of the degradation of livelihoods, food security systems and increased poverty. As a result, in the face of growing challenges to livelihoods posed by climate change, it is vital to sustain and improve existing traditional technologies while also importing scientific technologies, new transformation expertise, and innovative ideas to respond to the changing situation. Variations in vulnerability and adaptive capacity exist within the research area's communities. Depending on the livelihood options available, access to resources, access to knowledge, and a variety of other characteristics related to livelihood prospects, there is variance in susceptibility and adaptive capability within groups that live in the studied area. Inequality between men and women which is prevalent at household levels means that women stand out as being disadvantaged due to restrictions by traditional practices and marginalization. The marginalization of women and other social groups reduces possibilities for community resilience.

7.3 Recommendations

7.3.1 Recommendations for practical action

Climate change has had a major influence on livelihoods in the research area, according to this study. Traditional adaptive strategies are insufficient for those living in the region to adapt to climate change and variability, as evidenced by declining agricultural productivity, rising poverty levels, food insecurity, degradation of water resources, changes in weather patterns, a lack of climate information, a lack of early warning systems, poor adaptive capacity, and low liability, according to the research. To help increase livelihood well-being and socio-economic growth, existing conventional tactics should be combined with scientific strategies. It is the responsibility of the national and county governments, in collaboration with all stakeholders (researchers, politicians, administrators, private sector, donor institutions, communities, NGOs, and practitioners), to encourage and raise awareness about the impacts of climate change on livelihoods among people living in the region. From the study a number of recommendations for practical actions were suggested to help farmers cope and adapt to the whims of climate change. The following are some of the suggestions:

- **For the purpose of reducing food insecurity, the government and stakeholders should encourage small-scale farmers to increase food production**

Because livelihoods depend on food security at all family levels, it is important to support the implementation of specialized social protection programs to ensure that everyone has access to the food security they need for a healthy lifestyle. The small-scale farmers can increase food production through promotion of sustenance of Climate Smart Agriculture (CSA) This can be accomplished by application of chemical fertilizers, planting the correct seed and planting at the right time of the year. Crop varieties that take a long period to mature should be planted during the long rain periods while those that take a short time to mature can be grown during the short rain periods. To achieve this innovation, farmers should be given an opportunity to access the climate information so they can be able to make informed decisions and plan ahead. Long term climate change projections will help experts to advise the smallholder farmers on whether to invest in cropping systems and livestock rearing or not. There is need to set up financial institutions that can lend loans to farmers for the purpose of investment to boost agricultural production in the research area.

- **The government of the day to help farmers access climate information critical for informed decision making**

Accessing climate information and understanding impacts of climate change is critical to adaptive decision making in transforming livelihoods. In order for communities in the study area to effectively adapt to climate change, their wealth of indigenous knowledge must be integrated with scientific technical information that enables informed decision making to resolve societal problems. Communities should be sensitized on the value to use integrated traditional (experiential) and scientific (non-experiential) knowledge to foster socio-economic development and improve livelihoods. Adaptation strategies aim to reduce the vulnerability or enhance resilience at household level in the study area.

- **The National and County government to assist farmers diversify livelihoods strategies to build adaptive capacity and enhance resilience**

Diversification of livelihoods strategies is a fundamental strategy in building adaptive capacity and resilience but it must be done in an informed and empowered way in order for it to be effective. The decision to diversify is always driven by recurrent climate shocks and stresses to existing livelihood strategies. Engaging in new activities requires new skills and transformation knowledge that may not exist in the traditional communities that requires capacity development and technical assistance from external actors and experts.

- **The government and the stakeholders should assist the smallholder farmers to choose, use, and capitalize to better their livelihoods and well-being through innovative adaption technologies**

The government should assist the smallholder farmers need to choose, use and capitalize on adaptation help enhance their livelihoods and well-being through technology, while enabling them to respond effectively to continuous and unpredictable climate change. To achieve food security and economic development, systems of food production and trade systems must be made more accessible for smallholder farmer. Funds from Green Climate Fund (GCF) as per the Paris Climate Change Conference 2015 must be made available for the smallholder farmers so that they can achieve their food production targets. Not all ofthis money will be invested in agriculture, but some will go into other sectors of investment to secure and improve livelihoods.

Most of the financing will likely be offered as loans, not grants, to enable replenishment of the Climate Fund.

- **The National and County governments and the stakeholders to put in place early warning systems**

The National and County Governments should give early warning information on climate change using various ways to ensure that the information is successfully communicated to all parties. The systems will be used to tell residents of the area about how to prepare the land, when to plant, when not to plant, and which seeds to plant. Farmers will be told whether they should use organic or chemical fertilizers to boost their harvests at the end of the season. Useof the media can be of great importance because most of the people listen to local radio stations and watch TVs. However, phone cells are mostly considered to be more effective means of communication to pass across the required information without hesitation. Most of our people are illiterate or semi-illiterate and therefore the use of native languages or mother tongues can enable the information or message reach the small-scale farmer down in the village. The early warning information can help the farmers prepare adequately and plan ahead of time.

- **The government and the stakeholders to carry out reforestation by planting indigenous trees to mitigate climate change through carbon sequestration**

Forests are well-established carbon ‘sinks,' absorbing billions of tons of CO. Forests help to mitigate climate change by storing carbon and providing economic, environmental, and social cultural benefits. Forests enhance water retention capacity, which minimizes flash floods, especially during droughts, and they also serve as a carbon ‘sink.' Sustainable livelihood activities, good planning, and decisive policy management should be stressed to combat deforestation as a pragmatic integration activity into national legislative policies to better minimize the rate and impacts of deforestation Forests are well-established carbon ‘sinks,' absorbing billions of tons of CO. Forests help to mitigate climate change by storing carbon and providing economic, environmental, and social cultural benefits. Forests enhance water retention capacity, which minimizes flash floods, especially during droughts, and they also serve as a carbon ‘sink.' Sustainable livelihood activities, good planning, and decisive policy management should be stressed to combat deforestation as a pragmatic integration activity into national legislative policies to better minimize the rate and impacts of deforestation. Hence, communities should protect forest resources as a way forward to mitigate their own livelihoods.

- **The government and stakeholders to train the youth and the women in entrepreneurship to transform the quality of livelihoods and foster sustainable development**

Entrepreneurship is the development of a business enterprise from a concept or idea. It entails generating an idea and turning it into a successful business. It is a risk undertaking that involves the exploration of an opportunity and risk management in order to generate profit. Training in entrepreneurship will enable the participants attain an opportunity to become innovators and increase their creativity through the acquisition of technical skills and information. People who are trained in entrepreneurship will be able to formulate development strategies, long term policies and shared future visions for generations to come. Participants will benefit from the program by developing adaptive ability, reducing livelihood threats, and practicing sustainable land, water, and livestock management in the face of climate change.

- **The National and County governments to educate the people to embrace the potential for changes in gender roles and relations**

Climate change is a driver to changes in gender roles and relations. As the impacts of climate change become more apparent, households in the study area are increasingly required to shift from traditional livelihood strategies and practices, and embrace potential for changes in gender roles and relations. Within households and communities, men and women have different roles and levels of adaptive capacity. It is imperative that vulnerability and adaptive capacity must uncover these differences and build an understanding of the specific roles, responsibilities and challenges faced by both men and women in securing livelihoods.

- **The governments of the day to encourage households embrace potential for changes in gender roles and relations**

Climate change is a driver to changes in gender roles and relations. As the impacts of climate change become more apparent, households in the study area are increasingly required to shift from traditional livelihood strategies and practices, and embrace potential for changes in gender roles and relations. Within households and communities, men and women have different roles and levels of adaptive capacity. It is imperative that vulnerability and adaptive capacity must uncover these differences and build an understanding of the specific roles, responsibilities and challenges faced by both men and women in securing livelihoods.

7.3.2 Future research

Based on the present findings, more research in the future should be conducted focusing on:

- To evaluate the effectiveness of various climate change forecasting methodologies, as well as how these changes affect people's lives and socioeconomic growth in the study area.
- The relationship between human activities and climatic conditions, as well as present livelihood vulnerability and resilience, must be established.
- Household questionnaire surveys, FGDs and KIIs detailed study should be strengthened to build on the present findings in order to document similarities.
- More research is needed to discover and understand the physical elements that influence the study area's year-to-year and seasonal climate fluctuations. This knowledge would be required in order to improve rainfall early warning predictions.

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APPENDICES

Appendix 1

1: Questionnaire for the livelihood survey

1. Questionnaire number: ..... ……..
2. Interview date: .....
3. Place of residence: village or town: …….
4. Interviewee's name: .....
5. Date of data entry: ..... ……..
6. Data input officer: .....

Section 1: The respondent, his or her family, their means of subsistence, and their vulnerability

7. Respondent's name.....
8. Date of birth.....age.....
9. Respondent's sex.....
10. Relationship inside the household.....
11. Specify marital status.....
12. Children sighed: males..... females…….....
13. Indicate where you were born: village, town, elsewhere in the nation, or abroad.
14. Educational level: none / primary / secondary / tertiary / technical / other.....
15. Ethnicity / mother tongue.....
16. Indicate your religion: christian / muslim / buddhist / hindu, or other.....
17. Occupation of the respondent: farming / livestock / fishing / trading / salary work / Other non-farm income / farm labour / housework / student / Unemployed…….....
18. Composition of household: men……women ……boys…… girls……..
19. Number of household members involved in livelihood activities that provide food or income? … …….....

1.2 Land use/agricultural activities

20. Do you have any land in your family? yes, or no... …….....

a. If yes, how does your family make use of the land? crop farming/stock raising / fallowing /

nothing / other … …….....

b. If so, what is the size of your land in units? ……

21. Do you have any farming operations on your property? yes/no..... (if no, move to the next section) …….....

22. In the current season, how much land did you cultivate? Unit ……..,,,,,,,,,,,,,,

23. Do you own all or part of the land you farm? yes/no…….....

a. Do you rent, borrow, or share this land? yes/no?

24. Do you use irrigation on any of your land? yes/no……... a. Do you irrigate any land? If so, how much land do you irrigate? Unit ……...

25. Name three crops you grew in the previous season (in order of importance)? a)…… b)……. c)……....

26. Did you cultivate the land with a tractor or animal traction? a)……....

b) Did you do it on your own?.....

27. Do you hire outsiders to work on the land? yes/no..... a. If yes, estimate how the total number of 'persons days' per year……..... 28. What is the purpose of your crop production? consumption/sale ……..... 29. Do you normally sell all of your crop yield, more than half, about half, less than half, scarcely little, or nothing at all? specify: …….

30. What was your household revenue from agricultural sales in the last 12 months? …….....

31. In the last 10 years, did your crop production… 1=Decrease a lot | 2=Decrease a little | 3=Remain the same | 4=Increase a little | 5=Increase a lot

a) If decreased or increased, please indicate the cause(s):……..

b) If it increased or decreased, indicate the likely cause(s): ……....

1.3 Livestock rearing and planting of economic trees

32. Do you or anyone in your family keep livestock? Please list the number of (1) fowls, (2) goats and sheep, (3) pigs, (4) cows, and (5) donkeys you have. ..... a. If yes, name one key goal of cattle rearing: household consumption, traction, or sale. …….....

b. How much money did you make from farming livestock in the past?

33. Do any of your family members participate in fishing? yes/no……..... a. If yes, select one of the following options: fishing, fish raising, or both..... b. What is one of the benefits of keeping fish? ..... c. How much money has your family made from fishing in the last 12 months? ……..... 34. Do home trees (wood or fruits) have economic value? ..... a. If yes, what is the primary function of economic trees? (specify) domestic consumption/sale/other.....

b. Please provide the following information about the total number of economic trees held by your household: / (2) 10 to 50 / (3) >100 / (4) 50-100 …….....

1.4 Additional sources of revenue

35. Do you or certain members of your family participate in any non-farm activities? yes/no. specify……

If so, how many members of the family are involved in non-farm activities? a. Describe the activities in which your family members are involved. petty business .....bigger company.....white collar wage work.....blue collar salary work b What is the total estimate from non-farm activities? .....

36. Does your family get remittances from migrant relatives or friends? .....

a. If so, from whom? (choose) parents / son / daughter / brother / sister / other.....

b. What is the location of the remitters? Specify if it is within the region, another region, or beyond the country.....

c. How much money did you get in the pajama party? .....

37. Do any members of your family work on other people's farms? yes/no..... a. If so, how many people live in your home? ..... c. Please estimate the total number of person days in the previous year..... b. Please calculate the total annual income earned during the last year..... 38. Are there any additional sources of income except those mentioned? .....

a. If yes, specify the source..... b. Please state the entire annual revenue earned in the previous year.....

39. Please state the amount of money your household has on hand on a regular basis: quantity..... currency.....per (underline time unit): week, month, or year

40. In comparison to other households in your village/town, would you say your monthly income is less than most others/average/more than most others?.....

1.5 Housing and other assets

41. Do you own the house in which you live? (choose) yes/no … …….....
42. Indicate how many homes you own in addition to the one you live in. …….....
43. What are the building materials of the house you live in? …… a. Roof: iron sheets / roofing tiles / concrete / natural materials / other (choose)…… b. Walls: iron sheets / cement blocks / baked bricks / sun-dried bricks: …… 44. What is the number of bedrooms in your home? (choose) 1.....2.....3.....4..... 45. Is the house where you reside of lower, average, or higher quality than other dwellings in your town / village? (select) yes / no.....
46. Do you have a powerline in your home? (choose) yes/no …….....
47. How do you obtain your drinking water? well / borehole / pump / surface water / pipe / other, (select).....
48. Do you have a private lavatory in your home? 48. (choose) yes/no... …….....
49. Do you have any of the following assets in your household? [insert the number of people] a) a computer.....b) a cell phone .....(c) motorcycle .....(d) bicycle .....(e) automobile... .....(f) refrigerator .....(g) television .....

1.6 Food security

50. How many meals do adults in your household consume on a daily basis? .....
51. How many meals do your children consume on a daily basis in your home? .....
52. Have there been any months in the last year when you had to eat less? (choose) a. yes/no..... If you answered yes, list the months when this occurred. January / February / March / April / May / June / July / August / September / October / November / December /
53. Has your family faced any food shortages in the last ten years? (choose) yes/no .....
a. If so, how many in a ten-year period? .....
b. What are the most common reasons of food shortages? .....

2. Impact of and coping with weather-related extreme events

55. In the last two decades, where have you lived? (choose) a region or a sub-county .....

2.1 Open Questions

56. Which threat has had an impact on your family? (Select) (the most serious / the most recent). Specify the year. ..... 57. Explain how this threat has impacted your agriculture operations. . .....

58. Did this extreme have any bad consequences for your family? (explain) .....

59. What did your family do to cope with the effects on your farming systems? yes / no

60. If you said yes, what did you do despite your meagre resources?.....

61. If not, why not? (select) didn't know what to do / no financial resources / lack of skills / knowledge / lack of other resources / It's not a priority / not very important to us / not my task / responsibility / other / it's not a priority / not very important to us / it's not my task / responsibility / other (explain)..... 62. What was your family's experience when you stopped taking meals?

2.2 Closed questions: unusual occurrences (impact & coping)

64. Have you ever experienced a flash flood in your home? (choose) no / yes .....

65. If so, how did it influence your family? (explain) .....

a. Did it have an adverse impact on crops? (choose) / no / moderate / severe / na If the word "explain" is used in a mild or severe way, estimate costs .....

b. Did the livestock suffer as a result? None / mild / severe / na / If the word "explain" is used in a mild or severe way, estimate costs .....

c. Did it have an adverse impact on fishing? None / mild / severe / na / , If the word "explain" is used in a mild or severe way, estimate costs .....

d. Has there been any detrimental impact on the economic trees? None / mild / severe / na Explain if it's mildly or severely.....estimate costs: .....

e. What is the impact on business and trade? None / mild / severe / na / If moderately or severely, explain.....

f. What was the extent of the property damage? (choose) None / mild / severe / na / If moderately or severely, explain.....

g. Choose from the following options: none, moderate, severe, or na ..... Explain / estimate costs if moderately or severely: .....

h. What are the other negative impacts? (select) none, moderate, severe, or na .....

Questions about what people did to cope with (impacts of) extreme events:

66. Did you beg for food or money from others to help you deal with this? (select) yes or no.....

67. Did an organization provide you with any assistance in dealing with this threat? (choose) no / yes .....

68. Have you or any of your family members attempted to supplement your income in order to

69. Did you or any of your family members flee the area because of the threat? (choose) no / yes..... a. If yes, for how long? (Select) short-term vs. long-term ..... b. If so, where should I go? (select) within region / other region / abroad.....

70. Was the location to which you relocated rural or urban? (choose) rural vs. urban.....

71. Did you try to reduce your spending in response to this threat? (select) no / yes.....

72. Did you alter your eating habits in response to the threat? (choose one) no / yes.....

73. Did you do anything else to deal with the extreme event? (choose) no / yes,.....

74. Did the actions or steps you made to deal with this threat go far enough to prevent negative consequences for your household's living standards and well-being? (choose) yes / no ..... Why (explain).....

3. Impact of adaptation to slow onset climatic changes

3.1 Open questions

75. Were the actions or procedures you took to deal with this threat sufficient to prevent ne

76. Has your village/town experienced any variations in flood frequency or intensity in the recent two decades? (choose) yes / no .....

77. How do these changes in the environment affect you? Did these dangers have an impact on your livelihood activities, such as agricultural systems?

78. Did your family take any action in response to developments in threats to agricultural activities? (select) yes / no..... (if no, skip next two questions)

79. If you said yes, what did you do? .....

80. Do you believe that, despite the precautions you made to protect your family from the threat,

you are still experiencing negative consequences as a result of changes in threats? Why? (explain)

.....

81. If not, why not? (select) I don't know what to do / I don't have enough money / I don't have enough skills / knowledge / I don't have enough other resources / It's not a priority/not very essential to us / It's not my task/responsibility / other a. (explain).....

82. What are the negative consequences of having a pet in your home? .....

3.2 Closed questions: slow onset climatic changes (impact + adaptation)

83. Have there been any significant changes in threats in the last two decades? Yeah, a lot / yes, but only a bit / approximately the same / no, less than before / not at all

84. Does it have a negative impact on your household's financial status, if yes/no? (choose one) yes, a lot / yes, but only a little / no, it has no bearing on us

85. If so, how does it influence your family?

a. Negative impact on crops: none, moderate, severe, or not applicable (na) If moderate/severe, (explain)

b. Impact on livestock: none, moderate, severe, or na If moderate/severe (explain).....

c. Negative impact on fishing: one, moderate, severe, or non-existent If moderate/severe, (explain).....

d. Tree crop negative effects: none, moderate, or severe na If the condition is moderate or severe (explain) .....

e. Negative trade impact. Food price impact: none, moderate, severe, or na

f. If the condition is mild or severe (explain).....

g. House/property damage: none, moderate, severe, or (na)

h. Other unfavourable effects, describe if mild or severe (explain). 0 / 1 / 2 / 3 / 4 / 5 / 6 (na) If moderate/severe (explain).....

Questions about what households do/did to adapt to (impacts of) climatic changes:

86. Did you alter agricultural production in response to threats? Why do you have to pick between no and yes? (explain).....

87. Did you engage in non-farm activities to deal with changes in threats? (choose) no / yes ..... Why? (explain).....

88. Have you or your family members migrated as a result of changing threats? (choose) / no yes 140

89. Have you done anything to deal with dangers that have changed since you last dealt with them? (choose one) no / yes.....

90. How did you deal with negative repercussions on your household's living standard and well-being? No, there are still severe negative consequences / no, there are still mild unfavourable consequences / yes, it permits us to continue / yes, it has even helped our condition (explain).....

4.0 Vulnerability, gender and policy

91. Do you believe that other households in your community are less or more likely than yours to be affected by dangers in your neighbourhood? (choose) more, average, or less a. Why? .....

92. The effects of these climatic threats varies for men and women. Why? .....

93. Are men and women capable of playing various roles in the face of climate change? (explain) ..... 94. Do you believe the government or other groups can take steps to mitigate the effects of climate change? .....

Appendix 2: Details of key informant interviewees

Below is a list of the details of informant interviewees conducted face to face at their work

S/No.	**Position in Society**	**Date of interview/ location**
1	Ass. Sub –County Education Officer.	Education office on 7th Feb. 2016
2	Head of Biko Kapkoret Radio Station	B.K. Radio Station on 11th Feb. 2016
3	Head of Nzoia Water Company	N-Water Off. on 16thFeb. 2016
4	District Medical Officer	Mt. E. Dis. Hos. on20th 2016
5	District Crop Officer	Dist. Crop Off. on 25thFeb. 2016

6	District Livestock Officer	D. L/stock Off. on 28th Feb. 2016

Appendix 3: Average annual rainfall (in mm.) for the period 1986 - 2015

Year	Average annual rainfall (in mm.)
1986	76.45
1987	97.28
1988	105.63
1989	109.48
1990	98.77
1991	104.54
1992	106.12
1993	95.53
1994	106.87
1995	104.15
1996	97.03
1997	104.44
1998	136.79
1999	98.51
2000	85.88
2001	122.87
2002	96.14
2003	115.06
2004	94.18
2005	88.14
2006	121.56
2007	130.25
2008	103.45
2009	105.40
2010	125.04
2011	127.42
2012	128.23
2013	123.09
2014	106.28
2015	113.05

Appendix 4: Average temperature (degrees Celsius) for the period 1986 - 2015

Year	Average temperature (degrees Celsius)
1986	19.73
1987	18.73
1988	19.20
1989	18.10
1990	18.30
1991	18.62
1992	18.95
1993	18.67
1994	18.90
1995	18.48
1996	18.19
1997	18.70
1998	18.64
1999	18.32
2000	19.23
2001	19.30
2002	18.88
2003	18.56
2004	19.86
2005	19.68
2006	19.63
2007	19.18
2008	19.19
2009	19.41
2010	19.51
2011	19.77
2012	19.32
2013	19.54
2014	19.76
2015	20.03

Appendix 5: Summary of rate of responses

Response	Frequency	Percentage
Amount of food bought	374	97.40 %
Coping strategies adopted by households	376	97.92 %
Crop production	1,030	268.23 %
Education	398	100.00 %
Livelihood diversification	398	100.00 %
Livelihood sources	1,298	338.02 %
Marital status	398	100.00 %
Modification of food consumption	366	95.31 %
Months of food shortage in the past year	807	210.16 %
Non-farm income activities	379	98.70 %
Perceptions of change in threats (20 years)	370	96.35 %
Perceptions on crop yield trends	375	97.66 %
Religion	398	100.00 %
Sale of crops	398	100.00 %
Sex of the respondents	398	100.00 %
Total	**7,679**	**1999.74 %**

Appendix 6: Summary of failed responses

Response	Frequency	Percentage
Amount of food bought	10	2.60 %
Coping strategies adopted by households	8	2.08 %
Modification of food consumption	18	4.69 %
Non-farm income activities	5	1.30 %
Perceptions of change in threats (20 years)	14	3.65 %
Perceptions on crop yield trends	9	2.34 %
Total	**64**	**16.67 %**

Appendix 7: Details of Kapsokwony Division fact sheet

Information Category	Statistics
Division area:	
Total area (km^2)	58.4
Water mass	Not determined
Gazetted Forests (km^2)	Not determined
Arable land	Not determined
Non arable	Not determined
Total urban areas (km^2)	2
Topography and climate:	
Temperature (^0C)	0 - 20
High	0 - 27
Low	1,800
Rainfall	1,400
High	
Low	
Demographic Profiles:	
Total Population	Approximately 100,000
Total Male population	Approximately 49,000
Total Female population	Approximately 51,000
Population growth rate (%)	3%
Population density	475 persons /km^2
Poverty Indicators:	
Absolute poverty (5%)	56
Contribution to national poverty (%)	0.5
Food poverty (%)	56
Household Income expenditure (Kshs.)	80

Agriculture Rural self-employment Wage employment Urban self-employment	5 5 10
Crop farming: Average farm size (acres) Percentage of farmers with title deeds Total acreage under food crop (ha) Total acreage under cash crop (ha) Total acreage under soil/land conservation (ha)	 4 25 8,000 50 205
Livestock farming: Main livestock bred Cattle Sheep Goats Donkeys Pigs Land carrying capacity (animals/area)	 Approximately 494,963 Approximately 306,815 Approximately 182,683 Approximately 48,402 Approximately 5,465 0.75 17,779.5

Fisheries production: Fishermen (No.) Fish farm families (No.) Fish ponds Main species of fish catch Fish harvest	 18 4 11 Tilapia ssp., Trout spp., brubus ssp., synondotis ssp., and clarius ssp. Weight 56; Value (Khs.) 3,765
Wildlife Resources: Animal types Game management (National parks/ reserves)	Commonly seen; Elephants, red duiker, buffaloes, oribi, waterbuck, bushbuck, giant forest hog, leopard, spotted hyena, rodents, wild cat and civet. Nil
Health and Sanitation: District Hospital Health centers Dispensaries Private clinics	 1 1 4 5
Environment: Number of rivers and wetlands Number of climate change adaptation projects/programmes Number of renovated quarries Mining activities Solid waste management site	 5 1 Not determined Not determined Not available

Water Resources:	
Households with access to piped water	438
HH with access to portable water	1,340
Number of permanent rivers	5
Number of swallow wells	59
Number of protected springs	46
Number of un-protected springs	Nil
Number of dams	1
Number of bore-holds	6
Households with water catchment roofs	14
Mean distance to nearest water point	0.5
Number of Water Resource User Association (WRUA)	1
Households with latrines (%)	62%
Forestry:	
Number of gazetted forests	1
Number of non-gazetted forests	Nil
Size of gazetted forests (ha)	Approximately 12,642
Size of non-gazetted forests	Nil
Seedlings production	Approximately 105,000
Farms engaged in farm forestry	Approximately 90,000
Average number of trees per farm	50
Non – timber forest products harvested	
Fuel – woods (head – lots)	3.8
Honey (Kgs,)	10,000
Community Forest Association (CFA)	1
Quantity of timber produced (m^2)	Over 15,000
Energy:	
Trading centers with electricity	2
Trading centers without electricity	6
Health facilities with electricity	1
Health facilities without electricity	7
Secondary schools with electricity	2
Secondary schools without electricity	5
Households connected to national grid	0.4
Households not connected to national grid	Not determined
Household that rely on fuel wood for heating	2.8
Households that rely on solar energy	Not determined
Households that rely on paraffin for heating (%)	95
Households that rely on charcoal for heating	1.8
Education:	
Number of ECDE centers	45
Number of trained ECDE teachers	50
Number of untrained teachers	40
Gross enrolment rate (%)	85
Net enrolment rate (%)	75
Number of primary schools	24
Number of trained primary school teachers	327

Teacher/pupil ratio	1:48
Total enrolment	17,259
Dropout rate (%)	13
Number of secondary schools	9
Number of secondary school teachers	62
Teacher/pupil ratio	1:25
Total enrolment	646
Gross enrolment rate (%)	75
Net enrolment rate (%)	55
Dropout rate (%)	18
Public University	Nil
Private University	Nil
No. of National polytechnics	Nil
No. of Youth polytechnics	1
Literacy Levels	
Ability to read	81
Can read (%)	24
Ca not read (%)	76
Ability to write	25
Can write (%)	
Cannot write (%)	

Appendix 8: Sample questions asked during Focus Group Discussions (FGDs)

1. What are your thoughts on the last 30 years' worth of historical climatic patterns?

2. Do you believe that changes in weather patterns have had any impact on the region's livelihoods?

3. What impact will changes in weather patterns have on people's livelihoods over this time period?

4. Has crop output in the area increased or decreased over the years?

5. Has the region's livestock rearing been affected by changes in climate patterns?

6. How has climate change affected people's livelihoods in the study area?

7. How have local residents adapted to shifting weather patterns in order to maintain their livelihoods?

8. What are the coping adaptive techniques that residents in the area are using to maintaintheir livelihoods?

9. How effective are the coping adaptive measures at eradicating poverty and improving livelihoods?

10. What policies do you think will assist to eliminate poverty and enhance people's lives?

Appendix 9: Sample questions asked during Key Informant Interviews (KIIs)

1. What are your primary sources of income?
2. How do you think your community's climate (rainfall and temperature) is changing?
3. Do you have any traditional methods for predicting rainfall? If so, what are the methods?
4. How frequently does your area encounter drought?
5. Can you offer the years and names of major droughts that occurred in your area?
6. How has climate change impacted your way of life?
7. Has climate change had an impact on your finances?
8. How has climate change changed vegetation, land use, and cattle species?
9. Has a new human or animal disease emerged as a result of the drought in your area?

Appendix 10: Sample questions asked during Key In-depth Interviews (KIIs)

1. How have you adapted to climate change and variability using coping strategies?
2. How do you feel about the rising rates of poverty?
3. What coping methods do you believe will be effective in alleviating your community's risingpoverty levels?
4. How can you diversify your income in order to mitigate the negative effects of climatechange on your household?
5. What organizations help your communities cope with the drought?
6. Do you always have government assistance during drought? If yes, how do they assist?
7. Do you believe the government could do more to mitigate the effects of climate changeand variability?
8. What role do non-governmental organizations (NGOs) play during a drought?
9. What do you believe the most significant priorities are currently for assisting thecommunity in adapting to climate change and variability?

Appendix 11: Summary of rate of responses

Response	Frequency	Percentage
Amount of food bought	374	97.40 %
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